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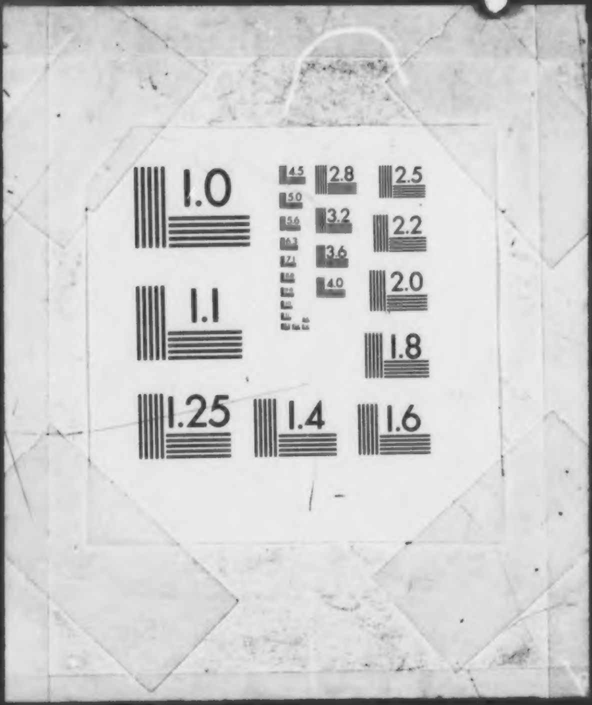
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Environmental Assessment of Alternative Seafood Waste Disposal Methods at Akutan Harbor, Alaska

Jones and Stokes Associates, Inc.
Sacramento, CA

Prepared for

Environmental Protection Agency, Seattle, WA

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This Environmental Assessment evaluates alternative methods of disposing of seafood processing wastes produced at Akutan Harbor, Alaska. It evaluates the impacts of these alternatives on water quality, harbor sediments, benthos, biology, beneficial uses of the harbor, the village of Akutan, and the seafood processing industry.

The sheltered harbor at Akutan, an island in the Aleutian chain of Alaska, offers protected waters for processing ships. One large land-based processing plant was built on the harbor in 1982 by Trident Seafoods Corporation. It burned to the ground in June 1983; the owners plan to rebuild. No NPDES permit has ever been issued for the plant. One objective of this Environmental Assessment is to provide information to EPA that can be used to assist in developing permit conditions for the Trident plant and in reviewing permits for floating processors.

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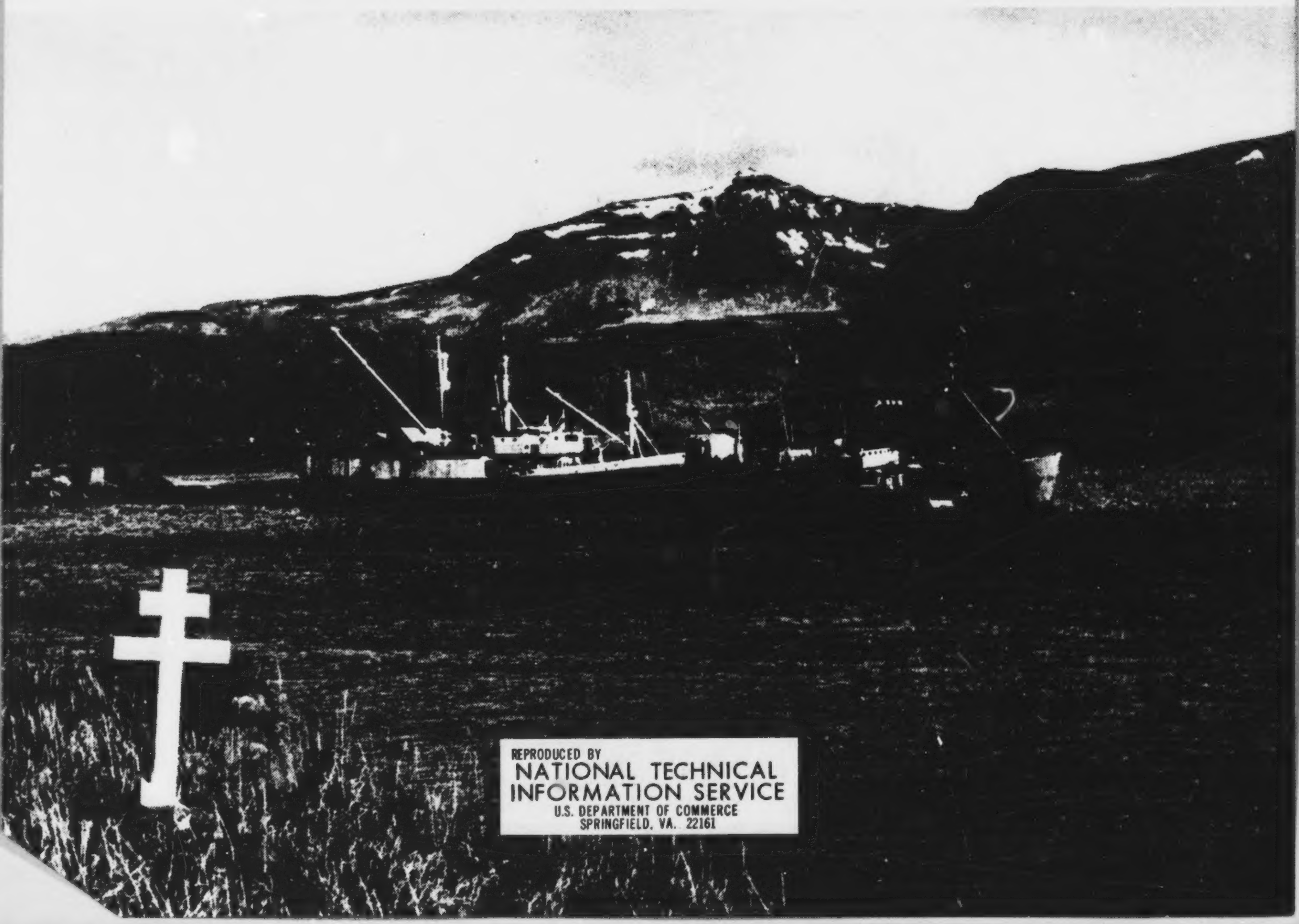

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ENVIRONMENTAL ASSESSMENT OF ALTERNATIVE SEAFOOD WASTE DISPOSAL METHODS AT AKUTAN HARBOR, ALASKA

Prepared for:

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Under Contract No. 68-01-6613
Work Assignment No. 9

Prepared by:

Jones & Stokes Associates, Inc.
2321 P Street
Sacramento, CA 95816

1802 136th Place NE
Bellevue, WA 98005

and

Tetra Tech, Inc.
1900 116th Avenue NE
Suite 200
Bellevue, WA 98004

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Chapter 1

SUMMARY

This Environmental Assessment evaluates alternative methods of disposing of seafood processing wastes produced at Akutan Harbor, Alaska. It evaluates the impacts of these alternatives on water quality, harbor sediments, benthos, biology, beneficial uses of the harbor, the village of Akutan, and the seafood processing industry.

The sheltered harbor at Akutan, an island in the Aleutian chain of Alaska, offers protected waters for processing ships (Figure 1). One large land-based processing plant was built on the harbor in 1982 by Trident Seafoods Corporation. It burned to the ground in June 1983; the owners plan to rebuild. No NPDES permit has ever been issued for the plant. One objective of this Environmental Assessment is to provide information to EPA that can be used to assist in developing permit conditions for the Trident plant and in reviewing permits for floating processors.

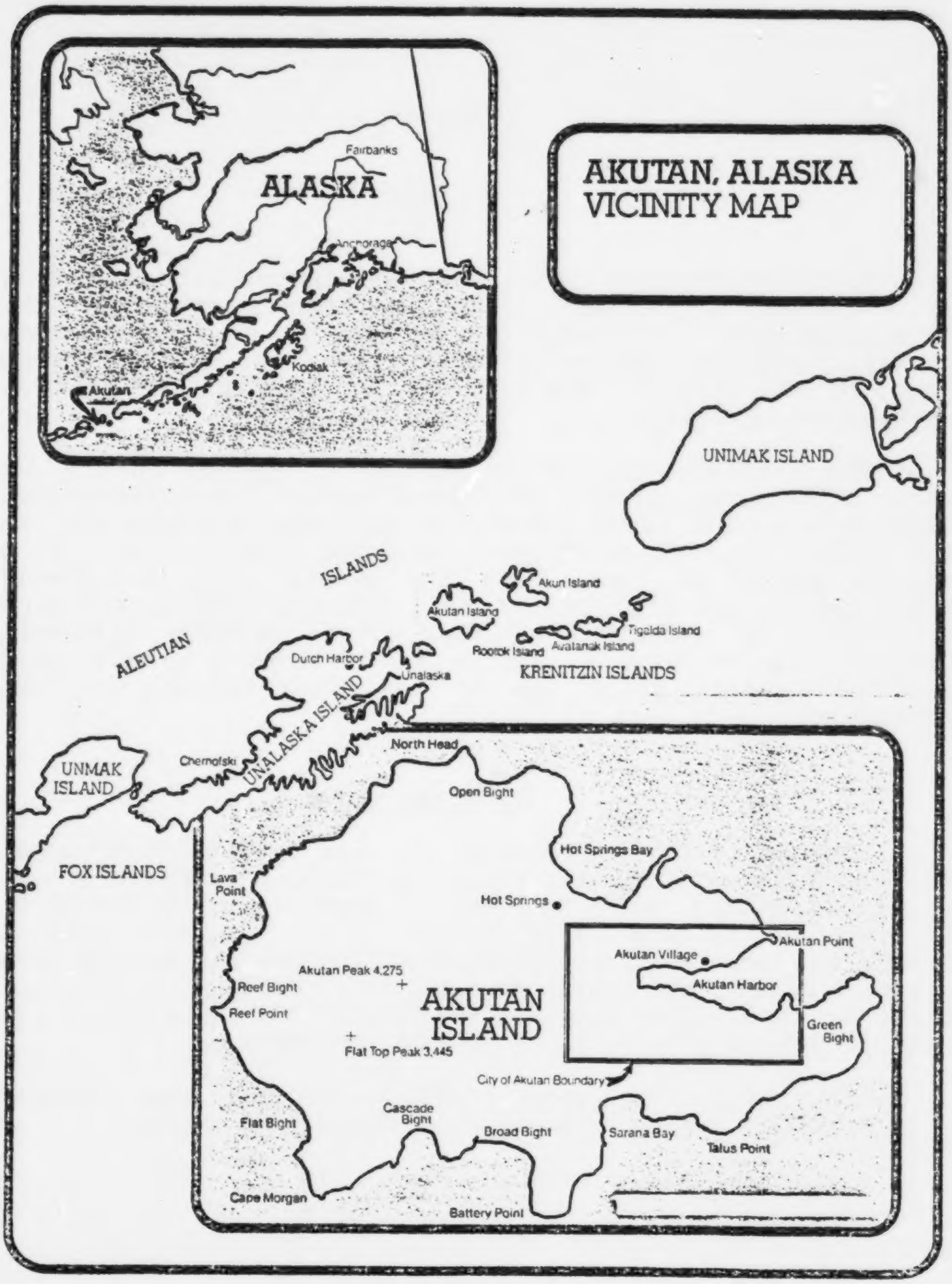
Alternatives

The alternatives addressed in this Environmental Assessment are those potentially available to seafood processors operating in Akutan Harbor. EPA can impose permit conditions that allow or require specific alternatives (e.g., grinding and outfall discharge, screening and barging of processing solids to deeper water) or can set conditions on the quality of the discharge that, in turn, place the responsibility for selection of acceptable treatment alternatives on the processors.

Generally, the waste handling alternatives addressed in this document can be grouped into four categories:

- initial waste quantity reduction
- treatment without solids separation
- solids separation and disposal
- solids reuse

The alternatives generally do not address treatment of the liquid fraction of the waste stream.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ALASKA
Fairbanks
Anchorage
Kodiak
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Tigalda Island
Rootok Island
Avatanak Island
KRENITZIN ISLANDS
Dutch Harbor
Unalaska
UNALASKA ISLAND
Chernofski
UNMAK ISLAND
FOX ISLANDS
North Head
Open Bight
Hot Springs Bay
Hot Springs
Lava Point
Akutan Point
Akutan Village
Akutan Harbor
Akutan Peak 4,275
Reef Bight
Reef Point
AKUTAN ISLAND
Green Bight
Flat Top Peak 3,445
City of Akutan Boundary
Cascade Bight
Flat Bight
Broad Bight
Sarana Bay
Talus Point
Cape Morgan
Battery Point

SOURCE: CITY OF AKUTAN 1982.

FIGURE 1. GEOGRAPHIC LOCATION OF STUDY AREA.

The following sections briefly describe these alternatives, address relative effectiveness, estimate costs, and describe environmental impacts.

Initial Waste Quantity Reduction

Maximum utilization of the raw product during seafood processing would result in smaller quantities of waste, thus reducing additional treatment needs. The majority of crab processed in Akutan Harbor is frozen as sections, which produces a minimum amount of waste. The majority of cod processed at Trident's land based plant is wet salted; however, some filleting occurred. Minced meat recovery has been successfully applied to filleting lines and can recover approximately 35 percent additional product. Additional product recovery can include fish heads, roe, milt, and organs. Other seafoods processed at the Trident plant undergo efficient processing techniques.

No costs are estimated for this alternative, since costs are highly specific to each processor's operations.

Environmental benefits would accrue through decreased solids discharges. Water quality, sediment quality, and marine benthos would be less affected by decreased solids discharges.

Direct Outfall Discharge Without Treatment

Direct discharge without at least grinding the waste is not an allowable alternative for remote areas of Alaska under current federal regulations (40 CFR 408). The impacts of such a discharge include the accumulation of larger size waste particles and decreased decomposition rates, compared to grinding. Cost impacts on processors would be the least of any of the alternatives.

Direct Outfall Discharge with Grinding

One option would be to continue the current practice of grinding seafood waste prior to discharge to Akutan Harbor. The effluent guidelines and standards for canned and preserved seafood (40 CFR 408) require that processors in remote areas of Alaska grind seafood waste to 0.5 inch (1.27 cm) diameter before discharge. Grinding increases the surface area and decomposition rate of waste in an oxygenated environment. The BOD loading from a seasonal discharge with grinding is thus exerted over a shorter time period than without grinding. Grinding, however, also increases the dispersive character of the waste, spreading the BOD loading over a larger area.

For the Trident plant a significant waste pile would develop. About 11 acres of bottom was covered by the pile in March 1983 after less than one year of operation (Evans Research Group, Inc., 1983). If the plant operates at full capacity, the pile could cover 22-93 acres in four years, depending on the assumptions used. Pile depth could increase from about 8 meters (March 1983) to 11-23 meters or more. The pile would stabilize in size after about 4-5 years due to decay.

Another problem exists at the Trident waste pile in that the outfall continually discharges fresh wastes up through the center of the waste pile, not unlike a volcano. This discharge will mix with the interstitial waters of the waste pile that, under anoxic conditions, will have significant dissolved concentrations of hydrogen sulfide, ammonia, and possibly methane. This will degrade the quality of the effluent that eventually enters the water column, but may increase the decomposition rate of the disturbed wastes.

Quantification of the impacts of discharging effluent through a decomposing waste pile are difficult to estimate. Factors that need to be considered include: waste depth, discharge frequency and duration, discharge volume, interstitial volume, decomposition rate and processes, and waste characteristics. Qualitatively, the potential for effluent of very low quality exists when effluent must flow through an anaerobic waste pile. A water quality impact would be greatest when discharge commences after a period of no discharge.

In summary, the impacts of this alternative include adverse effects on water quality, sediment quality, marine benthos, and marine vertebrates. The alternative imposes costs on the seafood processors consistent with current conditions.

Outer Harbor Outfall Discharge with Grinding

Extending discharge pipes to better flushed areas may result in better dispersal and less environmental impact. Such an outfall at Akutan would most likely need to extend to the mouth of the harbor for adequate flushing and waste dispersal. Large accumulations could develop if flushing is not adequate. Care must be taken in placing the discharge so that navigation is not impaired and that the pipe will not be broken by boat activity, including anchoring.

Costs are high for such underwater pipe extensions, and the impacts on water quality, sediment quality, and marine benthos depend on the degree of dispersion and any resulting benthic accumulations.

Screening with Barging of Solids for Ocean Dumping

Removing solids from the waste stream removes a significant percentage of the total solids, BOD, and COD. The most common method of solids separation uses screens of various types and sizes. Other methods of solids separation include settling, centrifuging, and initial dry separation on the processing line. The solids can then be conveyed by barge to deeper water for dumping. Barging for Akutan is expected to cost from about $290,000 to $350,000 per year, including amortization of capital costs and operations.

Barging at Akutan would require year-round operation for the Trident facility but only seasonal operation for the floating crab processors. A viable option for processing in the harbor would involve a cooperative barging system with collection of all wastes into one barge.

Selection of an appropriate ocean dumpsite would be necessary prior to dumping. Site criteria should be such that minimal impacts would result from bottom accumulations and pollutant loadings.

The advantages of seafood waste disposal via barging to deeper water for the Akutan Harbor area include removal of wastes from the protected inner harbor, flexibility in deposition area, and implementation of a relatively simple and proven procedure. Disadvantages associated with this alternative include: the possible need for storage during inclement weather; attraction of vermin during filling; odor during storage; handling, and transport; no revenue product generated; and the need for designation of a dumping site.

Impacts on water quality, sediment quality, and marine benthos would be decreased. The possibility of odor impacts would exist, and the processors would have to bear the cost of barge purchase and operation.

Screening with Landfilling of Solids

Solids could also be disposed of by landfill burial. No landfill exists on Akutan Island, so this alternative would require landfill construction, as well as solids separation, collection, transport, and landfill operation and maintenance. Collection would depend on the mode of transportation. Wastes could be transported via barge vessel, truck, or possibly pipe. The landfill would require vehicles for moving and covering the wastes. Over 6 acres/year of land could potentially be impacted by landfill disposal.

Land is scarce, transportation would require both boat and land vehicles (or pumping), significant odor problems are possible, landfill leachates could affect surface water resources, and the cost impact on the seafood processors would be greater than for barging.

Screening with Aerobic Digestion and Discharge of Solids

This alternative would involve screening followed by grinding and active mixing of solids in a digestion tank followed by discharge to marine waters. This process has been successfully applied to organic sludges produced from wastewater treatment plants (Metcalf & Eddy, Inc. 1979). Its application to seafood wastes has not been tried but is theoretically possible. About 35 acres of land would be needed; it is not available at the Trident facility. Thus transport would also be required, increasing the cost significantly above barging to open ocean.

The major advantage of this alternative would be the reduction in solids and BOD loading. This would result in less accumulation on the harbor bottom. Disadvantages include the required land area, unproven technology on seafood wastes, energy consumption, possible odors, and no new product recovery or offsetting revenues.

Screening, Centrifuging, and Incineration of Solids

This alternative would require screening and centrifuging of solids prior to combustion in a furnace. A multiple hearth furnace has been used successfully on municipal wastes and sludges (Environmental Associates, Inc. 1974). Environmental Associates (1974) concluded that seafood wastes are too wet and of too low fuel value to render this alternative economical.

A cost estimate for fuel requirements alone yields a cost of $240,000 to burn one year's waste. Additional cost would include capital cost of the incineration facility, skilled labor, and ash transport. There would be no product recovery and offsetting revenues; although the solids would be converted to an inert ash, odor impacts could occur. Impacts on water quality, sediment quality, and marine benthos would be substantially reduced assuming ocean disposal of the ash.

Screening with Production of Seafood Meal and Oil from Solids

Seafood meal and oil can be produced from seafood wastes by solids separation, cooking, drying, packaging, and transportation. The separation of fish oil is a necessary step in the fish meal process and yields a marketable product and a waste fraction called stickwater. Adding the stickwater to the solids for drying increases the solids recovery and is termed a whole fish meal process. Bagging the final meal product is necessary when bulk transportation is not available. A deodorizer reduces air pollution and odor impacts.

A capital investment of about $5.0 million and about 1 to 2 acres of land would be needed to construct a fish meal plant in Akutan, with a total annual operating cost (including amortization of capital and transportation to market) estimated to range from $2.6-$5.4 million, depending on amount of processing, oil yields, energy efficiency, and financing. Market values of end products indicate that revenue generated could range from $2.7-$6.7 million, depending on processing volume and yields. A potential annual operating profit for an energy efficient plant with 18 percent financing and 2 percent oil recovery is shown to range from $71,000 to $1.3 million, depending also on amount processed. Annual profits could reach $2.37 million if oil recovery approaches 8 percent.

Shellfish wastes could also be processed to yield crab meal. When processed as a separate product, crab meal would not be profitable; it would require a subsidy of $50-$110 per ton to be marketable in Seattle. This is primarily due to the relatively low protein content of crab meal (30 percent) as compared to fish meal (60 percent). It may be possible to incorporate some crab wastes to produce a mixed meal product with a sufficiently high protein content to be profitable.

The advantages of meal and oil production from seafood wastes include removal of solids from the marine environment, proven technology, product recovery and revenue, and profit potential. Disadvantages associated with this alternative include high capital investment, distance to market, potential for odor problems, and energy consumption.

Screening with Production of Fish Silage from Solids

The Trident plant could undertake the production of fish silage, a form of liquified fish wastes, using either acid preservation or fermentation. The process requires solids separation, mincing, storage, and transportation.

This alternative was evaluated by Brown and Caldwell (1983) for Dutch Harbor, Alaska. It was concluded that fish silage could not be economically transported more than about 400 kilometers, eliminating any market for Akutan-produced silage. A fish silage facility at Akutan Harbor could produce approximately 25,500 metric tons annually and at a current market value of $100 per metric ton (approximately 20 percent of the market value of an equivalent volume of fish meal). Transportation costs to Seattle would make such an alternative economically unattractive.

Screening with Production of Chitin/Chitosan from Crab Solids

Chitin and its derivative, chitosan, is a natural polymer derived from shellfish wastes. The production of chitin is currently in the pilot stage of development. The variety of potential applications of chitin as a coagulant, for film forming, and as animal food makes commercial production possible in the near future, however. The conversion of shellfish wastes into chitin requires grinding, separating, acid demineralization, caustic deproteination, rinsing, drying, and transport.

The quantity of shellfish waste at Akutan Harbor is highly variable and has significantly decreased from the 1980 high. This waste is only produced for a short time during the crab season, but plant size would need to be based on daily waste production. Some storage of waste may be possible but final product quality may decrease. Therefore, a large plant would be necessary that would not operate for a major portion of each year.

A total annual cost of up to $1.1 million would be required to amortize capital investment and operate such a plant. Possible revenues are estimated at up to about $374,000, indicating a loss of about $750,000 per year.

Advantages of processing chitin/chitosan from crab wastes at Akutan Harbor include removal of seasonal shellfish wastes from the marine environment, and recovery of a marketable product. Disadvantages include unproven commercial technology, limited product market, odor potential, no reuse of the fish wastes produced at the Trident plant, and adverse economics.

Screening with Recovery of Other Fish By-Products from Solids

Other technologies exist for the conversion of seafood processing wastes into usable products. These products include hydrolyzed fish products, fish protein concentrates, pet food, insulin, pearl essence, and fish glue.

The economics of these options are not fully explored in this document. The fish meal plant alternative is the most comparable in terms of environmental impacts. Economic implications of recovering other by-products are more complex and beyond the scope of this assessment.

Constraints on Implementation

When evaluating the alternatives, it is necessary to consider special circumstances imposed by the remoteness of Akutan. The island's distance from centers of commerce adds several constraints to industrial activities that are not always present in the lower 48 states. These constraints include: lack of land for facilities; distance from any market (except possibly bait); lack of energy source; cold, wet weather conditions; limited fresh water supply; high cost for materials; lack of skilled personnel; high turnover rate; and high labor costs. The evaluations in the assessment attempt to recognize these constraints, particularly in costs.

Impact Summary

A summary of the relative impacts of seafood waste disposal alternatives is presented in Table 1. Fish meal production and production of other fish by-products appear to offer both economic and environmental advantages while disposing of seafood wastes. Screening of effluent with barging also offers environmental benefits, but does not offer economic return to offset capital and operations costs to the industry. These alternatives would reduce impacts on water and sediment quality and biological resources compared to the current practice of grinding with outfall discharge. The fish meal production and production of other fish by-product alternatives could be beneficial to the seafood industry and to other harbor uses if the by-products are profitable and if the by-products encourage additional business exchange without further adverse impacts to the harbor (e.g. odors, fuel spills from boats).

Table 1. Summary of Relative Impacts of Seafood Waste Disposal Alternatives

IMPACT/ALTERNATIVE	WATER QUALITY	SEDIMENT QUALITY	MARINE BENTHOS	MARINE VERTEBRATES	FRESHWATER & TERRESTRIAL BIOTA	COMMERCIAL FISHERIES	SEAFOOD INDUSTRY	HARBOR USE	CITY OF AKUTAN
Direct outfall discharge W/O treatment	-	- -	- -	-	0	0	+	0	0
Direct outfall discharge w/grinding	-	- -	- -	-	0	0	0	0	0
Outer Harbor outfall discharge w/grinding	-	- -	- -	-	0	0	-	-	0
Screening w/barging of solids for ocean dumping	-	-	-	-	0	0	-	-	-
Screening w/landfilling of solids	-	0	-	-	- -	0	-	-	- -
Screening w/aerobic digestion & discharge of solids	-	-	- -	-	0	0	-	0	-
Screening, centrifuging & incineration of solids	-	-	-	-	-	0	- -	0	-
Screening w/production of seafood meal & oil from solids	-	0	-	-	0	0	+,-	+,-	+,-
Screening w/production of fish silage from solids	-	0	-	-	0	0	+,-	+,-	+,-
Screening w/production of Chitin/chitosan from solids	-	-	- -	-	0	0	+,-	+,-	+,-
Screening w/recovery of other fish by-products from solids	-	0	-	-	0	0	+,-	+,-	+,-

+ Beneficial Impact

0 No impact

- Minor adverse impact

- - Major adverse impact

+,- range of possible impact

Chapter 2

INTRODUCTION

Akutan, an island in the Aleutian Island chain of Alaska (Figure 1), has become a major center for seasonal floating seafood processors. A sheltered harbor on the east side of the island offers protected waters for processing in proximity to fishing vessels in Bristol Bay crabbing areas. As many as 13 processors operated in the harbor in 1980; only a handful operated in the harbor in 1983 due to substantially decreased crab harvests.

In 1982 a major land-based processing plant was constructed by Trident Seafood on Akutan Island on the north side of the harbor. The plant had the capacity to process daily 600,000 pounds (272 metric tons) of salted split codfish and cod fillets, as well as some crab, herring, and salmon. The plant had processed 9.1 million pounds (4,100 metric tons) of finished codfish products and 1.4 million pounds (600 metric tons) of other products as of March 1983. The plant was destroyed by fire on the night of June 9, 1983; bunkhouses and other support facilities remain, and the owners plan to rebuild the plant.

The harbor and some of the processing facilities are illustrated in Plates 1-7 at the end of this chapter.

Need for EPA Action

The Trident plant operated without a permit during its existence. The owners applied for a permit after the plant had been in operation for some months. EPA issued a Section 309 order directing Trident to provide certain data on the plant's discharge; most data were never provided to EPA, and the agency has deferred permit issuance until adequate data could be obtained. It became necessary for EPA to study environmental conditions with its own resources. Although the Trident plant was destroyed, the owners plan to rebuild.

There is also a need to review permit conditions imposed on other operators in Akutan Harbor in light of the cumulative impacts of substantially increased total waste loading. This Environmental Assessment and the Water Quality Analysis Report have been prepared to provide factual information and to assist EPA in drafting permit conditions for the Trident plant and other processors in the harbor.

Objectives

EPA issued a work assignment under Contract 68-01-6613 to obtain information needed to issue new or revised permits to the processors to protect water quality and harbor resources.

The objectives of the work are to:

- Determine flushing action and consequent residence time of seafood processing wastes.
- Assess the impacts of seafood processing wastes on local water and sediment quality.
- Evaluate the costs and benefits of alternative seafood processing waste disposal methods.

The Water Quality Assessment Report describes the field work undertaken to meet the first two objectives.

Investigations of Akutan Harbor water quality were carried out by Jones & Stokes Associates in May and September 1983. The objective of the investigations was to assess existing water quality and sediment quality in the harbor and to evaluate the impact of seafood waste discharges and waste piles. Trident was processing only crab, not cod, during the June 1983 investigations, and only one other vessel was processing at the time. During the September 1983 studies only one floating processor was operating. Thus, there was no opportunity to obtain field measurements of impacts on water quality due to high volume processing. Some estimates of flushing and residence time have been developed.

This Environmental Assessment is intended to address the second and third objectives. EPA may impose permit conditions on the processors that require implementation of specific waste management alternatives. The agency could also set environmental standards for discharges that would require a processor to choose a new waste management method in order to achieve such standards. This assessment describes possible alternatives, explores economic and market implications, and evaluates the impacts of the alternatives on the environment and on the processors.

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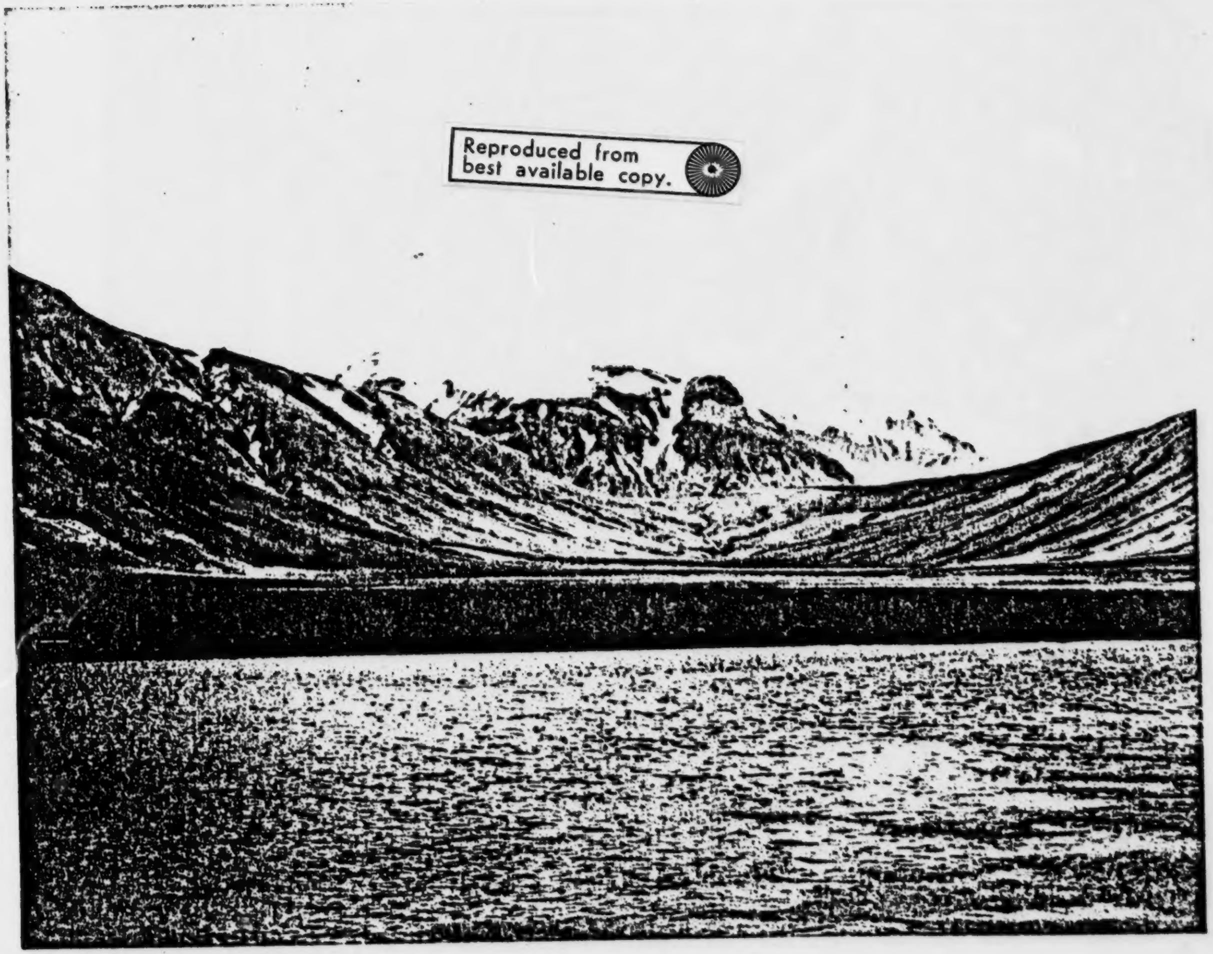

PLATE 1. VIEW OF THE VALLEY AT THE HEAD OF AKUTAN HARBOR LOOKING WEST.

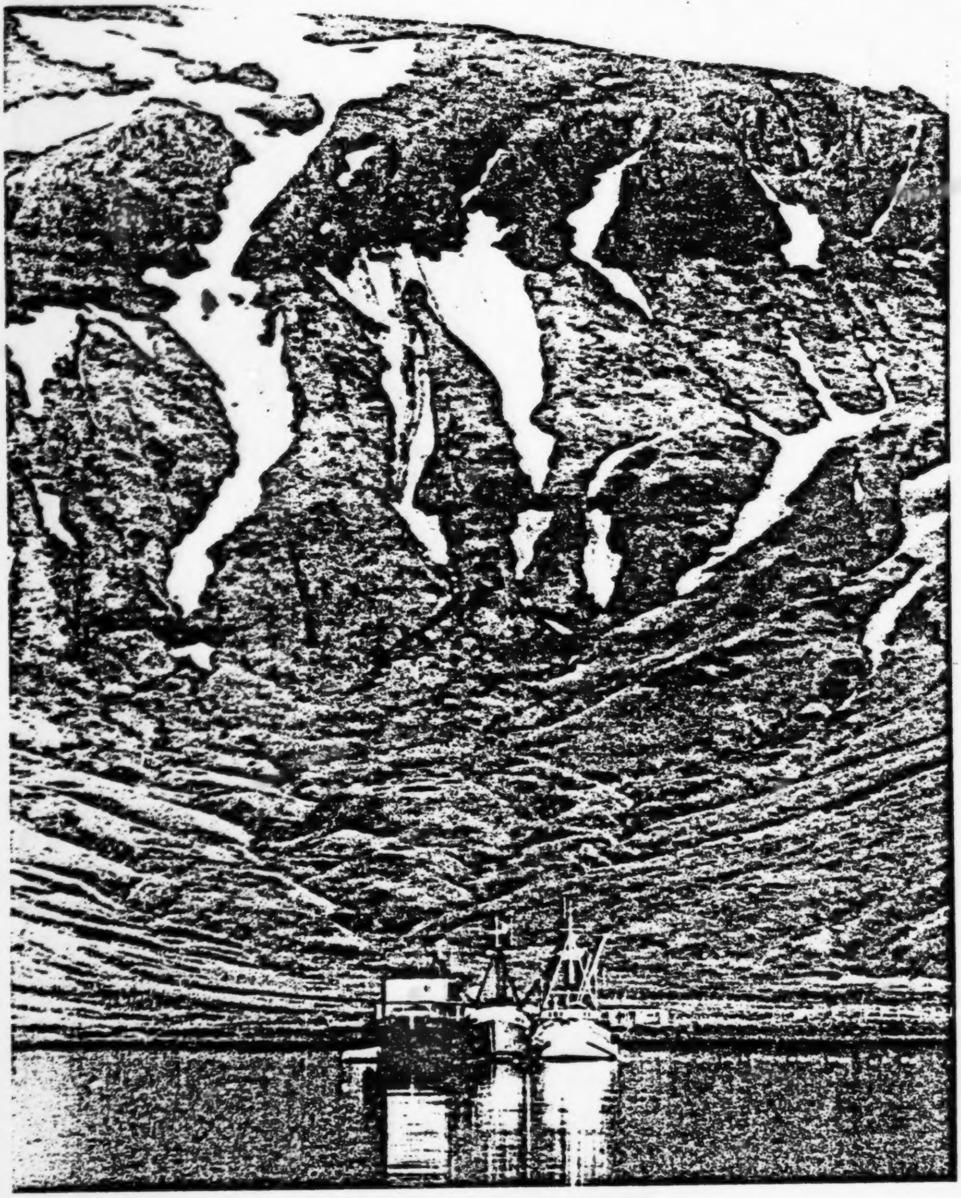

PLATE 2. M/V DEEP SEA (CENTER) , MOORED AT THE HEAD OF AKUTAN HARBOR.

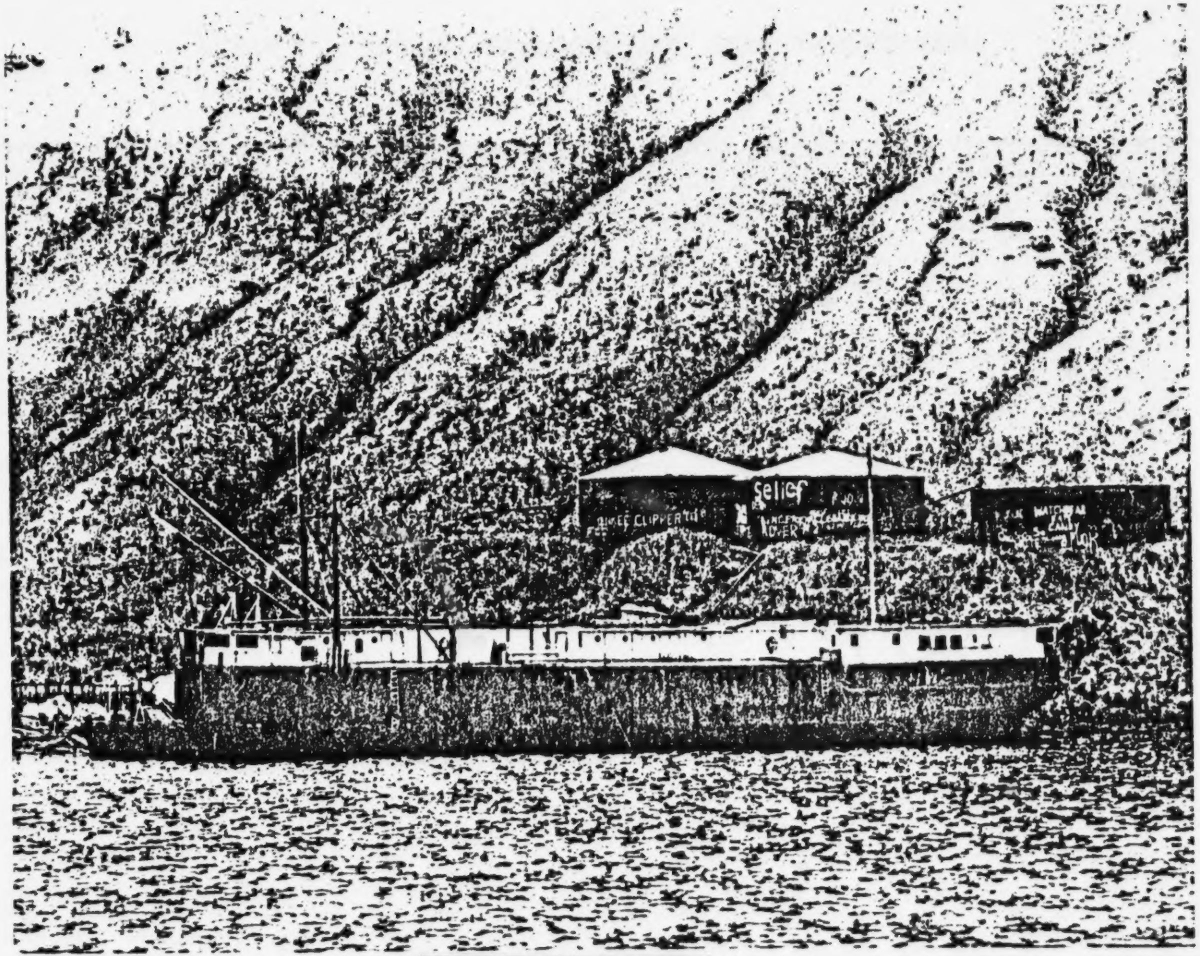

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PLATE 3.   M/V ALASKA SHELL, MOORED ON THE SOUTH SHORE OF AKUTAN HARBOR.

PLATE 4.   TRIDENT SEAFOODS, INC., VIEW LOOKING WEST

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PLATE 5. TRIDENT SEAFOODS, INC., VIEW LOOKING EAST

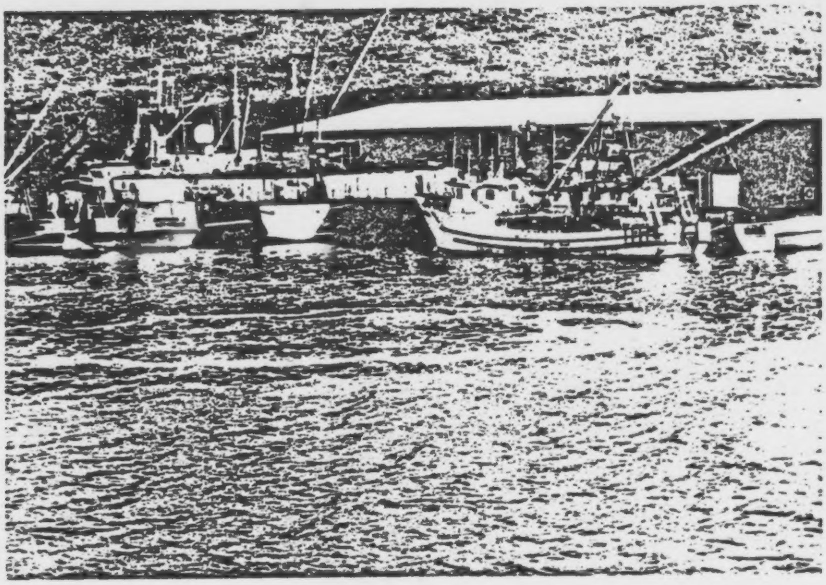

PLATE 6. EFFLUENT PLUME VISIBLE ON SURFACE AT TRIDENT OUTFALL DURING CRAB PROCESSING IN JUNE 1983. WHITE BUOY TO RIGHT OF SURFACED PLUME MARKS THE OUTFALL.

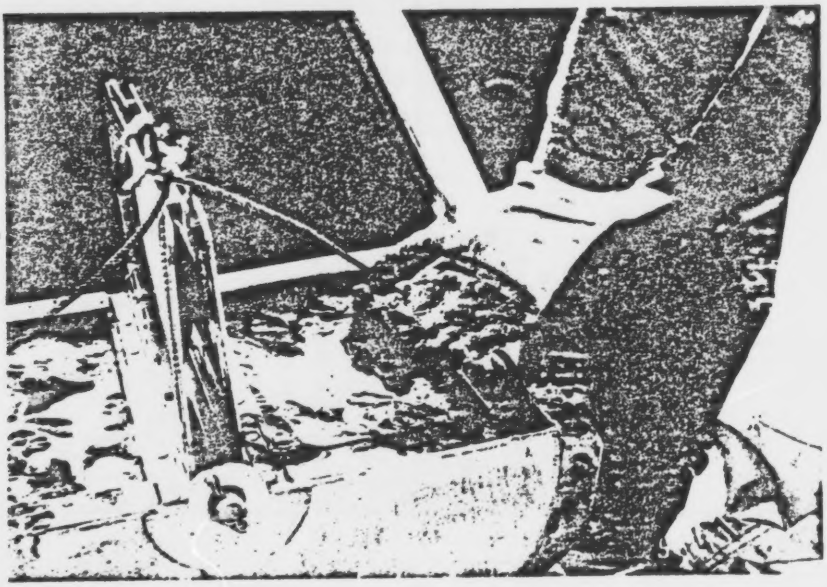

PLATE 7. VAN VEEN GRAB SAMPLE FROM TRIDENT WASTE PILE (SEDIMENT STATION 20).

Chapter 3

ALTERNATIVES

The alternatives addressed in this Environmental Assessment represent those potentially available to seafood processors operating in Akutan Harbor. EPA can impose permit conditions that allow or require specific alternatives (i.e., grinding and outfall discharge; screening and barging of processing solids to deeper water) or can set conditions on the quality of the discharge which in turn places the responsibility for selection of acceptable treatment alternatives on the processors. This chapter is intended to describe these options and their relative costs and set the stage for evaluation of impacts.

The alternatives for handling seafood wastes at Akutan Harbor cover a wide range of technically feasible options. Economic and environmental consequences of some options may deem them unacceptable. Generally, waste handling alternatives can be grouped into categories:

- initial waste quantity reduction.
- treatment without solids separation.
- solids separation and disposal.
- solids reuse.
- liquid waste treatment.

The alternatives generally do not address treatment of the liquid fraction of the waste stream.

The following sections describe these options, address their relative effectiveness, and estimate their costs.

Initial Waste Quantity Reduction

The reduction of waste produced during seafood processing can be a significant part of a total waste management plan. Modification of the production line and recovery of marketable products prior to waste designation will result in smaller quantities of waste, thus reducing additional treatment needs.

The efficiency of the production line in recovering the main seafood product has a direct relationship to waste reduction. Crab processing can be improved by producing sections and by recovery of tail meat. Efficient deheading and filleting methods can be used to recover the maximum finfish product possible. Nonfilleting processes, such as salting, utilize a significantly larger percentage of the raw weight.

The majority of crab processed in Akutan Harbor is frozen as sections, which produces a minimum amount of waste. The majority of cod processed at Trident's land based plant was wet salted; however, some filleting occurred. Other seafoods processed at the Trident plant used efficient sections or whole processes.

After filleting, the remaining fish is composed of bones and approximately 50 percent of the original meat (Pigott 1981). A portion (about 25 percent) of this remaining meat can be recovered as minced meat, creating a new product and decreasing the waste load. Also, small fish unsuitable for filleting can be partially recovered (about 50 percent of total weight) as minced meat. Additional product recovery includes fish heads, roe, milt, and organs. Foreign markets exist for consumption of salted fish heads (Dragoy pers. comm.), or heads could be collected and used as bait. Removal of fish heads, which constitutes 22 percent of the raw cod fish (Kizevetter 1971), could significantly reduce the wastestream. Salmon roe is currently recovered by some Alaskan processors and sold in foreign and domestic markets. The market for cod roe is not established. Milt is also recovered and marketed in Europe. The collection of cod livers and production of cod liver oil or paste would further reduce the wastestream.

The remaining wasted seafood parts (tails, carapaces, and viscera) could be sold as bait or, with additional treatment, transformed into a viable product.

Treatment Without Solids Separation

This category of waste management alternatives encompasses grinding and dispersal technologies. The main objective of treatment without solids separation is to aid in the natural decomposition capacity of the discharge area.

Direct Outfall Discharge with Grinding

One option would be to continue grinding of seafood waste prior to discharge to Akutan Harbor. The effluent guidelines and standards for canned and preserved seafood (40 CFR 408) require that processors in remote areas of Alaska grind seafood waste to 0.5 inch (1.27 cm) diameter before discharge. Grinding increases the surface area and decomposition rate of waste in an oxygenated environment. The BOD loading from a seasonal discharge with grinding is thus exerted over a shorter time period than without grinding. Grinding, however, also increases the dispersive character of the waste, spreading the BOD loading over a larger area.

The grinding and discharge of seafood processing wastes at Akutan has resulted in the buildup of waste on the harbor bottom near the discharge points. The decomposition rate and minimal dispersive action in the harbor have not been sufficient to avoid this impact.

Outer Harbor Outfall Discharge with Grinding

Flexibility exists in the location of the wastewater outfall and, with proper placement, decreased environmental impacts may result. Extending the discharge pipe to better flushed areas may result in better dispersal and less environmental impact. Such an outfall at Akutan would most likely need to extend to the mouth of the harbor to achieve improved flushing and waste dispersal. Care must be taken in placing the discharge so that navigation is not impaired and to ensure that the pipe will not be broken by boat activity including anchoring.

Solids Separation and Treatment

The remaining categories of alternatives include a solids separation step. This process is discussed below and would be used in conjunction with the remaining alternatives. These alternatives address only the treatment or reuse of the solids fraction. It is assumed that the liquid fraction will be discharged following separation.

Solids removal from the wastestream removes a significant percentage of the total solids, BOD and COD. The most common method of solids separation uses screens of various types and sizes. Other methods of solids separation include settling, centrifuging, and initial dry separation on the processing line. The wastewater stream passes through the separating device, which splits the waste into liquid and solid fractions. Further treatment can then be carried out on the two fractions more efficiently.

Screens can be classed as static, moving, and centrifugal (Green and Kramer 1979). Static screens filter the wastestream as it passes through under hydraulic head. The solids are collected and removed for handling. Occasional backwashing is necessary to prevent screen blockage. Moving screens assist the solids separation by vibrating or physically moving the particles from the water. These screens, though more complicated, do not clog as easily as static screens and are able to process larger volumes of wastewater. Centrifugal screens use centrifugal force to pass the wastewater through the screen, thus achieving high processed volumes.

A simple static screen, which has been used successfully in the seafood industry, is the tangential screen (Environmental Associates 1974). These screens use bars or meshing placed at an angle to the flow with a sloping surface. Wastewater flows over the screen with water passing through and solids moving down the screen face by gravity. Solids can easily be collected in a hopper placed at the screen's end.

Settling requires relatively passive storage of the wastewater to allow the solids to settle. Settling tanks, also known as clarifiers, are mainly used to provide this primary treatment. An advantage of clarifiers is the ability to remove fine particles that cannot be easily screened from the wastestream. Disadvantages include the need to dewater the removed solids, space requirements for solids storage, and settling time.

Solids separation using dry methods on the processing line can be very advantageous. Large solids, such as heads and carapaces, can easily be mechanically transported to collection areas, eliminating the need to remove them from the wastestream later. This also has the advantage of preventing additional leaching from these pieces that would decrease possible reuse value and decrease quality of wastewater.

Several alternatives exist for further handling of the solids and liquids once they have been separated. The solid reuse and disposal alternatives are discussed below along with a brief discussion of additional treatment for the liquid wastestream.

Brown and Caldwell (1983) estimated the cost of screening seafood processing wastes at Dutch Harbor. Based on that estimate, a tangential screening facility for the Trident plant would have a capital investment of approximately $68,000. Maintenance costs would be minor.

Solids Disposal

Disposal of waste solids can range from a relatively simple process to very complicated and energy-intensive processes. Alternatives include:

- collection and barging to open ocean, deep water discharge area.
- collection and transport to landfill.
- controlled digestion with subsequent discharge to receiving waters.
- incineration with land or ocean disposal of ash.

These four alternatives are discussed below as they might relate to seafood processing at Akutan.

Waste quantities have been estimated based on past processing records of Trident Seafoods, ADF&G shellfish production records, average final product recovery rates, and average body part weights.

The previous Trident facility had a production capacity of 600,000 pounds (272 metric tons) raw weight per day. Approximately 30-35 percent of the raw weight was processed into the final product, meaning that 65-70 percent or 390,000-420,000 pounds (177-190 metric tons) per day of maximum production would be waste requiring disposal. Assuming 15 production days per month year-round, 31,800-34,300 metric tons of liquid and solid waste would be discharged from the Trident facility. Shellfish production records between 1978 and 1982 indicate that an average of 7.4 processors operated in the harbor each year with 2,000 metric tons of raw product per processor. Assuming 40 percent waste for section processing (Brown and Caldwell 1978), an annual average of 6,100 metric tons of shellfish waste would be generated.

The total annual solid waste fraction of this waste would be approximately 29,000 metric tons. This waste quantity converts to approximately 24,500 cubic meters of cod waste and 3,800 cubic meters of crab waste using densities of 1.06 and 0.8 metric tons per cubic meter, respectively. During maximum production, approximately 144 metric tons of solid waste would be produced daily by the Trident facility. This is a maximum daily solids volume of 136 cubic meters.

Based on historical shellfish production, and assuming 30 production days, an estimate of 102 metric tons of crab waste solids per production day are generated. This is a production day solids volume of 85 cubic meters from all shellfish processing. Crab waste is directly proportional to the number of floating processors and this number has markedly decreased since 1980. In 1982 crab waste was estimated at only 40 metric tons of solids, equivalent to 33 cubic meters, per day. The seasonality of the crab harvest will govern the timing of crab waste generation, thus concentrating the required disposal/reuse effort into short periods in September-October and March-May. This varying level of waste production is not expected from the Trident facility except for possibly a lower production rate during the spring codfish spawning period.

Screening with Barging of Solids for Ocean Dumping

The disposal of seafood processing wastes by barging for ocean dumping requires solids separation, conveyance to barge, and barge transportation and dumping. Screened solids could be collected in hoppers to be emptied onto the barge periodically, or an automatic conveyer could be used for direct waste deposit onto the barge. Either self-propelled barge vessels or a towboat would be necessary to transport the wastes to a designated dumping site.

Brown and Caldwell (1983) investigated seafood waste alternatives for Dutch Harbor, including barging, using various vessels and cost estimates. Costs were divided into capital, operation and maintenance, towboat, and moorage. It is reasonable to directly apply these capital costs for the barge vessel to Akutan due to Akutan's proximity to Dutch Harbor. Operation and maintenance are also likely to be similar and are used in this analysis. The option of renting a towboat is not available for Akutan unless a processor would supply one, which could be used by other processors. Therefore, this cost category will differ for Akutan. The last cost of moorage is taken as zero for Akutan Harbor due to the ability of vessels to moor next to the floating processors or existing docks and buoys. Table 2 gives estimated barging costs based on the Brown and Caldwell investigation.

Caution is required in direct application of these cost estimates. Prices for equipment will vary with time, new or used condition, financing, special arrangements, and case by case. Savings may also be possible if personnel already employed can absorb the labor tasks. The small quantity of crab waste would also decrease the cost.

Barging at Akutan would require year-round operation for the Trident facility but only seasonal operation for the floating crab processors. A practical option for processing in the harbor would involve a cooperative barging system with collection of all wastes into one barge. Individual processors would be responsible for waste transport to the common barge and would share proportionally in the associated costs. This would decrease costs but would require cooperation between competing processors.

Selection of an appropriate ocean dumpsite would be necessary prior to dumping. Site criteria should be such that minimal impacts would result from bottom accumulations and pollutant loadings.

The advantages of seafood waste disposal via barging to deeper water for the Akutan Harbor area include:

- removal of wastes from protected inner harbor.
- flexibility in deposition area.
- implementation of relatively simple and proven procedure, compared to other alternatives.
- medium cost.

Table 2. Estimated Cost of Waste Disposal via Barging for Ocean Disposal at Akutan

CAPITAL COST		ANNUAL COST
Menhaden Vessel[1]	$200,000	
or Self-Propelled Barge	325,000	$ 37,000 - 62,000
or Barge	200,000	
and Towboat[2]	100,000	
(17 percent; 15-year life)		
OPERATION & MAINTENANCE		
Fuel & Oil ($200-300/trip x 150 trips)		$ 30,000 - 45,000
Maintenance		
Engines		16,000
Hull & Deck (12% of value)		17,000 - 34,000
Insurance (5% of value)		7,000 - 14,000
Labor (4 personnel)		182,000
Total		$289,000 - 353,000

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[1] Source: Brown and Caldwell 1983. Costs exclude screening of solids.

[2] Estimated purchase price.

Disadvantages associated with this alternative include:

- possible need for storage during inclement weather.
- attraction of vermin during filling.
- odor during storage, handling, and transport.
- no revenue product generated.
- need for designation of dumping site.

Screening with Landfilling of Solids

The disposal of seafood wastes by landfill burial would require solids separation, collection, transport, and landfill operation and maintenance. Collection would depend on the mode of transportation. Wastes could be transported via barge vessel, truck, or possibly pipe. The landfill would require vehicles for moving and covering the wastes.

A barge vessel could collect the wastes, as described above, then transport them to an unloading facility near the landfill. The unloading facility could pump the waste from the barge directly to the landfill or into a truck which would then proceed to the landfill. Storage would be needed at each processing location. Individual floating crab processors handle approximately 12 cubic meters per processing day. Storage would need to be provided for some fraction of this volume depending on transit time and storage logistics.

The Trident facility could use trucks to collect and transport the wastes, assuming a road could be constructed with permission of the City of Akutan. Thirteen to 26 trips per day from Trident to a landfill would be required using 5-10 cubic meter capacity trucks. A minimum of two trucks would be required. Snow cover in the winter and steep slopes along the shore would make such a land-based transport system very difficult.

Pumping of wastes to the landfill may be feasible for processors close to the landfill. Screening would occur at the landfill to remove excess water needed for pumping. Floating processors would need to take precautions to prevent pipe breakage due to boat traffic.

Land available for landfill is scarce in Akutan Harbor. The terrain is steep along the majority of the harbor, with very little beach. At the head of the harbor is a small valley, approximately 370 acres in size, which contains a potential landfill site previously studied by the City. Careful siting and design would be necessary to prevent leachate pollution and to meet state requirements. The annual waste volume of approximately 28,300 cubic meters would cover, at a 1 meter depth, 28,300 square meters or 7.1 acres. The majority of the near valley is owned by the Native Corporation (City of Akutan 1982) and would have to be obtained before land disposal of seafood waste could begin.

Various landfill alternatives were analyzed for the City of Akutan's municipal solid waste (Peratrovich, Nottingham, and Drage, Inc. 1982). It was determined that sufficient topsoil existed at the head of the bay for a landfill providing about 10,550 cubic meters of disposal volume. While the site would have a life of 4 to 8 years in accommodating municipal refuse and some processor trash, it is evident that seafood processing waste would fill the landfill in much less than one year.

Other areas of Akutan Island have not been studied for landfill development potential. In the Aleutian Islands generally, less than 5 feet of topsoil is present except in alluvial deposits from rivers (COE 1983, Dames and Moore 1980). It is likely that topsoil requirements (for cover as well as mixing/bulking material) for landfill disposal of seafood processing wastes could be met only by importing soils from offsite. In this case, substantially more than 6 acres per year of land could be disrupted.

A road from the unloading facility to the landfill would be necessary. Also, buildings for personnel and equipment maintenance are needed.

Cost estimates for a barging to landfill alternative would include costs for barging to open ocean and additional costs for:

- unloading facility.
- truck transport to site.
- land acquisition.
- landfill design.
- landfill equipment.
- associated buildings and roads.
- maintenance of facilities.

A detailed cost estimate has not been conducted due to this alternative's disadvantages, compared to barging to open ocean, and ADEC's general policy of not encouraging the landfill of seafood wastes (Brown and Caldwell 1983).

Advantages of landfilling seafood waste are limited to:

- the removal of the marine pollutant loading.
- containment of the wastes.

Disadvantages include:

- consumption of as much as 6.25 acres/year prime Akutan land.
- conflict with City-designated seafood processing center in landfill area.
- possible leachate problems.
- attraction of vermin.
- odors.
- possible gas production resulting from waste decomposition.
- no new product recovery.

Screening with Aerobic Digestion and Discharge of Solids

This alternative would require grinding and active mixing of solids in a digestion tank followed by discharge to marine waters. This process has been successfully applied to organic sludges produced from wastewater treatment plants (Metcalf & Eddy, Inc. 1979). Its application to seafood wastes has not been tried but is theoretically possible. Based on design criteria given by Metcalf & Eddy, Inc. (1979), and increasing residence time to 30 days, a capacity of about 425,000 cubic meters would be needed for the Trident waste. This is equivalent to 35 acres at 3 meters deep and thus would require significant land not available at the Trident facility. Thus, transport would also be required, which would increase the cost significantly above.that for barging to open ocean.

The major advantage of this alternative would be the reduction in solids and BOD loading. This would result in less accumulation on the harbor bottom. Disadvantages include the required land area, unproven technology on seafood wastes, energy consumption, possible odors, and no new product recovery or offsetting revenues.

Screening, Centrifuging, and Incineration of Solids

This alternative would require screening and centrifuging of solids prior to combustion in a furnace. A multiple hearth furnace has been used successfully on municipal wastes and sludges (Environmental Associates, Inc. 1974). Environmental Associates (1974) concluded that seafood wastes are too wet and of too low fuel value to render this alternative economical. Also, air pollution control devices and disposal of residual ash would be necessary. Approximately 1,400 metric tons of ash would be produced per year by the Trident facility. Some of this ash would be dispersed into the air as particulate matter.

A cost estimate for fuel requirements alone has been computed. Based on an estimated 26,000 metric tons of annual seafood waste from the Trident facility, 81 percent moisture (Kizevetter 1971), 3 percent oil, 7,000 cal/g oil, 10,000 cal/g fuel (Marks M.E. Handbook 1951), 100 percent heat transfer, and $1/gal fuel yields a cost of $240,000 to burn one year's waste. Additional cost would include capital cost of the incineration facility, skilled labor, and ash transport.

The municipality of Metropolitan Seattle evaluated the cost of incineration for sludge disposal for their Renton wastewater treatment plant (Metro 1983). This plant was sized for 70,000 metric tons of 18 percent solids annual sludge input. Two incinerators were included in the Metro system at $4 million each. Capital costs of an incineration facility at Akutan Harbor would likely include one incinerator of the same size and cost.

Advantages of incineration as a disposal option are:

- major weight and volume reduction of the wastes.
- conversion into a sterile ash.
- possible disposal of additional solid wastes.

Disadvantages include:

- energy consumption.
- potential air pollution.
- no new product recovery and no offsetting revenues.

Solids Reuse

Reuse of solid seafood wastes is defined for this report as any process that results in the recovery of a usable product. Alternatives include:

- seafood meal and oil.
- seafood silage.

- other fish by-products.
- chitin.

These alternatives are discussed below as they would relate to seafood processing at Akutan. Waste quantities were discussed previously in the Solids Disposal section.

Screening with Production of Seafood Meal and Oil from Solids

The production of seafood meal from seafood wastes requires solids separation, cooking, drying, packaging, and transportation. Windsor and Barlow (1981) present an extensive discussion of the fish meal production process. Figure 2 from Windsor and Barlow (1981) presents a generalized diagram of the fish meal process. Processing wastes could be deposited directly into the storage unit prior to cooking. The separation of fish oil is a necessary step in the fish meal process and yields a marketable product and a liquid waste fraction called stickwater.

Adding the stickwater to the solids for drying increases the solids recovery and is termed a whole fish meal process. Bagging the final meal product is necessary when bulk transportation is not available. A deodorizer reduces air pollution and odor impacts. The actual processes available may vary slightly from this generalized description because of improving technology and site-specific requirements.

A fish meal plant at Akutan would need to be designed for year-round processing of fish wastes and possible seasonal processing of crab wastes. The Trident facility operating at capacity (600,000 pounds/day or 272 metric tons/day) for 15 days per month would generate approximately 144 metric tons of solid wastes per processing day. This is equivalent to 71 metric tons per day, 365 days a year. A 100-metric-ton per day fish meal plant would meet the average waste processing needs, but would require that wastes be stored during peak production periods. A 150-metric-ton per day facility would not require extra storage for maximum production at Trident. The actual number of maximum production days per month will determine the appropriate size for a fish meal facility.

Provision could be made to incorporate shellfish waste processing in the plant. Floating shellfish processors produce a seasonal waste that would require transport to the facility and an auxiliary dryer. The 1982 daily estimated crab waste of 40 metric tons would require a 50-metric-ton per day auxiliary dryer for the assumed 30 production days.

Land requirements for a fish meal facility will vary based on actual plant design and warehousing needs. Considerable flexibility exists for plant layout including possible barge construction and vertical structures. Approximate areal requirements for a 136-metric-ton per day facility obtained from a plant manufacturer are given in Table 3 (Swafford pers. comm.).

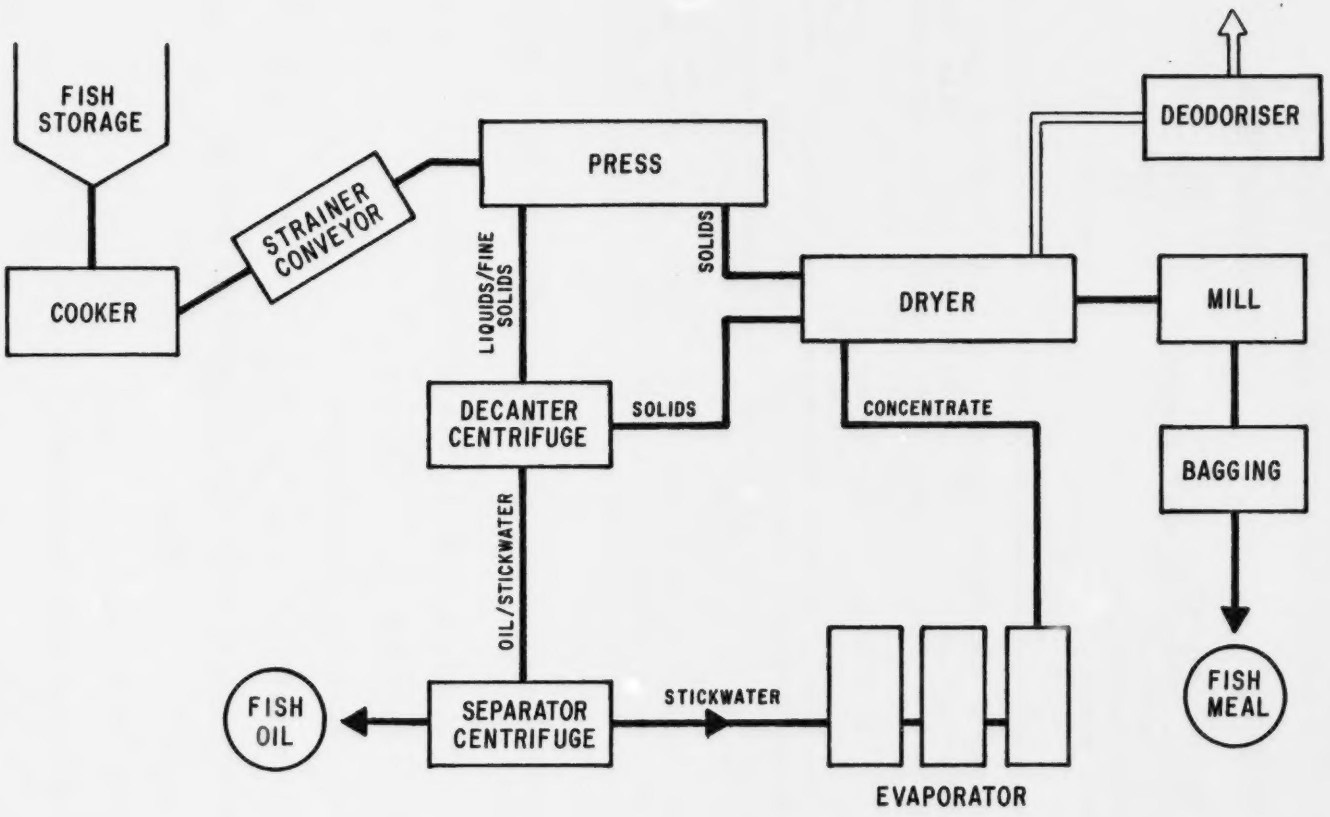
FISH STORAGE
COOKER
STRAINER CONVEYOR
PRESS
LIQUIDS/FINE SOLIDS
SOLIDS
DECANTER CENTRIFUGE
SOLIDS
DRYER
DEODORISER
MILL
BAGGING
FISH MEAL
CONCENTRATE
OIL/STICKWATER
FISH OIL
SEPARATOR CENTRIFUGE
STICKWATER
EVAPORATOR

FIGURE 2. PROCESS DIAGRAM FOR FISH MEAL PROCESSING

SOURCE: WINDSOR AND BARLOW 1981

Table 3. Example Areal Requirements
for a 136-metric-ton per Day Fish Meal Facility

COMPONENT	SQUARE METERS
feeding hopper	30
plant, including walk around	140
oil tanks (2)	10
meal handling	20
warehouse	varies

To approximate warehouse needs, a 136-metric-ton per day facility produces 27 metric tons of meal per day. This would fill 800 34 kilogram capacity bags and, based on 0.2 cubic meter per bag, occupy 160 cubic meters. Stored 3 meters high, and accumulated for a month, a warehouse of about 3,000 square meters would be required. Considering plant components, warehousing, handling space, conveyors, maintenance, energy system, and administration facilities, a minimum land area of slightly less than 1 acre is required. For comparison purposes, the fish meal facility at Kodiak, an 8-ton (7.3-metric-ton) per hour plant, is sited on less than 2 acres with significant expansion room and raw product unloading facilities (Gesko pers. comm.). Therefore, a 136-metric-ton per day facility at Akutan would require about 1 to 2 acres of land, with 2 acres providing a very spacious facility.

The advantages of meal and oil production from seafood wastes include:

- removal of solids from marine environment.
- proven technology.
- product recovery and revenue.
- profit potential.

Disadvantages associated with this alternative include:

- high capital investment.
- distance to market.
- potential for odor problems.
- energy consumption.

This alternative has been investigated for Alaska (Edward C. Jordan 1979; Development Planning & Research Associates

[DPRA] 1980) and Dutch Harbor in particular (Brown and Caldwell 1983). The Edward C. Jordan and DPRA reports present cost estimates for several Alaskan sites including Ketchikan, Petersburg, Cordova, Kodiak, and the Kenai Peninsula area. Three of these site evaluations indicated possible profit before taxes. The Dutch Harbor evaluation indicated that a fish meal plant at that location would not be profitable. Cost estimates in the above studies included capital, operation, maintenance, and product transportation. Revenue was based on meal and oil production and market prices. Revenue from fish oil was not included in the Dutch Harbor study.

Capital Costs. Edward C. Jordan (1979) estimated the cost of a 150-metric-ton meal facility equipped with a 70-metric-ton auxiliary dryer sited at Kodiak at $2,800,000 (1979 dollars). This facility is most applicable to Akutan Harbor. Brown and Caldwell (1983) estimated the cost of a 150-ton (136-metric-ton) meal facility sited at Dutch Harbor at $5 million. Based on these estimates, capital, operation and maintenance, and product transport costs have been estimated for a 150-metric-ton meal facility with a 50-metric-ton auxiliary dryer at Akutan.

Capital costs for a similar facility at Akutan Harbor would most likely be higher than the above estimates due to remoteness and lack of a sufficient resident labor force. Also, additional power generating facilities would be needed at Akutan, which would increase the necessary capital expenditure.

The remoteness of Akutan Island will require that the plant provide independent means of protection from certain hazards. In the case of fire, aid from Dutch Harbor can be several hours away during which time considerable damage may occur if insufficient local protection exists. Other hazardous conditions that may be of concern are volcanic activity, earthquakes, and high winds. Design and construction of facilities will need to recognize these hazards.

Edward C. Jordan (1979) used a construction cost factor for Kodiak relative to Seattle of 2.15. Assuming a factor of 3 for Akutan would result in a capital investment of $3.9 million (1979 dollars) based on Edward C. Jordan's data. When adjusted to 1983 dollars by the Engineering News-Record Index for construction costs, this capital investment is estimated at $5.4 million. A capital cost range of $5.0-$5.4 million (1983 dollars) has been selected for evaluation purposes.

The annual cost of amortizing the initial capital investment is a function of useful life and interest costs. The option of leasing the equipment also exists but is not explored in this report. To estimate annual capital costs, an interest rate which reflects the degree of investment risk and historical financial considerations of the investor must be used. With the prime interest rate currently at 11 percent, the minimum rate for obtaining plant financing likely would be 14 percent. If the venture is considered high risk because of potential variable harvests, widely fluctuating market prices, or other risk factors, a higher rate, such as 18 percent, would be appropriate. Assuming that the initial investment is amortized over 20 years, annual capital costs at 14 percent and 18 percent interest rates are estimated in Table 4.

Table 4. Estimated Annual Capital Costs for 150-metric-ton per day Fish Meal Facility at Akutan

INITIAL CAPITAL COST	ANNUAL COST	
	at 14% interest	at 18% interest
$5,000,000	$754,930	$ 934,099
$5,400,000	815,324	1,008,827

Operation and Maintenance Costs. Direct operation and maintenance costs included in the Edward C. Jordan report are operating labor, electrical power, fuel for steam generation and heat, equipment and building maintenance, and transport of final product to Seattle, Washington. This annual cost was estimated at $1,100,000 (1979 dollars). Subtracting the transportation fraction yields $530,000. This portion of the Kodiak facilities cost was for operation at about 50 percent capacity on an annual average. Based on average production at 71 metric tons per day, the Akutan facility would also operate at about 50 percent capacity. Maximum production year-round by Trident would utilize 95 percent of the fish meal plant's capacity, increasing the total direct operation and maintenance costs but reducing these costs on a per-ton basis. Operation and maintenance costs will be higher at Akutan because of remoteness and increased energy costs. Using the same ratio assumed for construction cost factors (2.15:3) and a linear increase due to higher utilization of capacity yields annual operation and maintenance costs of $1,018,000 and $1,934,000 (1983 dollars) for processing 71 metric tons and 144 metric tons per day, respectively.

The operation and maintenance cost per metric ton of meal produced is estimated as $183-$196. Brown and Caldwell (1983) estimate the operation and maintenance cost to be $152 per ton of meal ($167 per metric ton) plus a fixed annual operating labor cost of $174,000. At a 71-metric-ton per day capacity this fixed labor cost would add $33.50 to each metric ton of meal for a cost of $200 per metric ton; at 144 metric tons per day capacity, this would be a $16.50 increase or $184 per metric ton. These values agree with the estimated annual operating and maintenance costs of $1,018,000 and $1,934,000 ($183 and $196 per metric ton meal) for each respective production level.

The lack of surplus power facilities on Akutan means that a fish meal facility would need to generate its own electricity and heat. A separate energy evaluation was conducted to verify the above estimated operating costs. Estimates of fuel required to dry 1 metric ton of meal range from 50-66 gallons (Alfa-Laval 1983, Brown and Caldwell 1983). At $1-$1.25 per gallon, fuel costs for drying range from $50-$83 per metric ton. Electricity consumption estimates range from 180 kilowatts to 1,565 kilowatts (Alfa-Laval 1983, Brown and Caldwell 1983). Based on 10,000 calories/gram diesel fuel, 7 pounds per gallon, and 34 percent efficiency, 13-114 gallons per metric ton of meal or $13-$143 per metric ton of meal would be consumed.

Energy costs for an Akutan fish meal facility range from $63-$226 per metric ton of meal depending on plant efficiency, generator efficiency, and fuel cost. Table 5 summarizes the fuel costs and assumptions.

Table 5. Estimated Energy Costs per Metric Ton of Meal for Akutan Fish Meal Facility

FUEL PRICE PER GALLON	COST OF FUEL REQUIRED FOR DRYING	+	COST OF MINIMUM ELECTRICITY REQUIRED	or	COST OF MAXIMUM ELECTRICITY REQUIRED	=	TOTAL ENERGY COSTS
$1.00	$50-$66	+	$13	or	$114	=	$63-$180
$1.25	$64-$83	+	$17	or	$143	=	$81-$226

Adding fixed labor, variable labor, and bagging costs as estimated by Brown and Caldwell (1983) to the energy costs in Table 5 brings the total operation and maintenance cost per metric ton of meal to $142-$304 at the 71-metric-ton daily processing rate and to $124-$286 at the 144-metric-ton daily processing rate.

Therefore, the previously estimated operating cost of $183-$196 per metric ton is reasonable for a new energy-efficient fish meal facility. The effect of operating an energy-inefficient plant at $286-$304 per metric ton of meal is also presented in this evaluation.

Transportation Costs. Transportation of the finished product is an additional cost for a fish meal facility. Transportation costs (including terminal charges) to Seattle, Washington based on current rates from Sea Land Services, Inc. are $95.25 and $172.50 per metric ton for fish meal and oil, respectively.

Revenues. Annual revenues would result from the sale of fish meal and oil. Windsor and Barlow (1981) report yields of 21 and 11 percent of raw weights for meal and oil, respectively, while the Edward C. Jordan data indicate only 7 and 2 percent yields. The DPRA report used percentages of 20 and 8 for salmon meal and oil based on published sources, equipment manufacturers, and existing Alaskan fish meal processors. Using percentages of 20 and 2-8 for fish meal and oil yields, the meal facility at Akutan would produce 5,180 metric tons of fish meal and 520-2,070 metric tons of oil at the 71 metric tons per day production rate. This would increase to 10,500 metric tons of fish meal and 1,050 to 4,200 metric tons of oil at the 144-metric-ton per day production rate. With the current market value of fish meal at $478 per metric ton and oil at $396 per metric ton the annual revenue generated ranges from $2,682,000 to $6,682,000.

Cost Summary. Table 6 summarizes the annual costs and revenues in 1983 dollars for six combinations of assumptions for a fish meal plant using waste from the Trident Seafoods plant at Akutan. The values used in the evaluation are approximate and are based on Edward C. Jordan's 1979 report, transportation rates from Sea Land Services, Inc., and market value estimates from the Wilbur Ellis Company. The annual net economic value is positive for an energy-efficient fish meal facility operating at 50 percent capacity. The facility would have to operate at 33-44 percent capacity to amortize the annual capital cost of $5.4 million at 18 percent interest and defray operating expenses. Factors that aid in the economic feasibility of this alternative are:

- year-round processing.
- fish by-products instead of crab, yielding a higher-value product.
- improvements in fish meal production technology.

The economic feasibility of a fish meal facility is a function of the market value of its products. A decrease in the market value of fish meal or oil will decrease the revenue without changing the associated costs and thus decrease profits. Conversely, an increase in market value will result in an increase in profits.

In order for revenues to at least offset costs, the market value of product sold must be sufficiently high to equal the annual capital cost plus operation, maintenance, and transportation costs. Table 7 presents the break-even market values necessary for 12 sets of assumptions on the 71- and 144-metric ton per day facilities, assuming a constant oil market value of $396 per metric ton. At the current fish meal market value of $478 per metric ton, losses would result from the last two sets of assumptions.

Table 6. Estimated Annual Net Economic Value of 150-Metric-Ton Fish Meal Production Plant at Akutan (1983 dollars)

ASSUMPTIONS	CASE 1	CASE 2	CASE 3	CASE 4	CASE 5	CASE 6
Capital Cost[1]	5.0	5.4	5.0	5.4	5.4	5.4
Interest Rate	14%	18%	14%	18%	18%	18%
Plant Production Level[2]	144	144	71	144	71	71
Energy Efficiency	High	High	High	Low	High	Low
Oil Yield	8%	2%	8%	2%	2%	2%
Operation & Maintenance[3]	183	183	196	286	196	304
COST ANALYSIS						
Capital Amortization	$ 755,000	$1,008,000	$ 755,000	$1,008,000	$1,008,000	$1,008,000
Operation & Maintenance	$1,934,000	$1,934,000	$1,018,000	$2,989,000	$1,018,000	$1,578,000
Total Annual Production Costs	$2,689,000	$2,942,000	$1,773,000	$3,997,000	$2,026,000	$2,586,000
Transportation to Seattle	$1,740,000	$1,191,000	$ 854,000	$1,191,000	$ 585,000	$ 585,000
Total Annual Costs To Market	$4,429,000	$4,133,000	$2,627,000	$5,188,000	$2,611,000	$3,171,000
Projected Annual Revenues	$6,682,000	$5,435,000	$3,296,000	$5,434,000	$2,682,000	$2,682,000
Projected Annual Profit (Loss)	$2,253,000	$1,302,000	$ 669,000	$ 246,000	$ 71,000	$ (489,000)

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[1] Million Dollars. Excludes costs for screening solids

[2] Metric tons per day

[3] Operation and maintenance costs in dollars per metric ton

Table 7. Break-even Fish Meal Market Values For Akutan Fish Meal Plant

CASE (FROM TABLE 6)	PLANT CAPITAL COST[1]	INTEREST RATE	PLANT PRODUCTION LEVEL[2]	ENERGY EFFICIENCY	OIL YIELD	O&M[3]	BREAKEVEN VALUE[4]
Case 1	5.0	14%	144	High	8%	183	262
	5.0	18%	144	High	8%	183	286
	5.4	14%	144	High	2%	183	329
Case 3	5.0	14%	71	High	8%	196	348
Case 2	5.4	18%	144	High	2%	183	353
	5.4	18%	71	High	8%	196	397
	5.4	18%	144	Low	8%	286	407
	5.0	14%	71	High	2%	196	415
Case 5	5.4	18%	71	High	2%	196	464
Case 4	5.4	18%	144	Low	2%	286	474
	5.4	18%	71	Low	8%	304	505
Case 6	5.4	18%	71	Low	2%	304	572

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[1] Million dollars. Excludes costs for screening solids

[2] Metric tons per day

[3] Operation and maintenance costs in dollars per metric ton

[4] Dollars per metric ton at Seattle

Additional cost saving measures that could be implemented include substituting recovered fish oil for fuel oil, using a lower quality fuel oil, bulk transport of finished product, and transport to closer markets.

Inclusion of Shellfish Waste. The reduction facility could also process shellfish waste produced by the floating processors. This would require transport to the reduction facility and unloading equipment. Costs would be similar to the floating processors portion of the barging alternative plus meal production and transportation costs. Crab wastes require drying and grinding for meal production. The auxiliary dryer included in the fish meal plan evaluated above could also be used for shellfish processing. Additional operation and maintenance costs would consist of fuel for drying, electricity for grinding, bagging, and perhaps additional labor. Approximately 50-66 gallons per metric ton of meal are consumed in the drying process. This represents a cost of $50-$83 per metric ton of crab meal. The electricity required to grind the meal is assumed equal to 25 percent of the electricity required to operate the complete facility; 45 kilowatts to 391 kilowatts are estimated to be consumed by the grinder. Using a 34 percent efficient generator, 3-29 gallons per metric ton of crab meal would be required, adding $3 to $36 to the cost of each metric ton of this product. Bagging costs have been estimated (Brown and Caldwell 1983) at $16.50 per metric ton, resulting in a cost of $70-$135 per metric ton of crab meal, assuming no additional labor costs are involved. Transportation costs are estimated to be the same as for fish meal, or $95 per metric ton, bringing the crab meal cost to $165-$231 per metric ton at Seattle. The value of crab meal at Seattle is about $110 per metric ton, which indicates a net loss for this product of $55-$120 per metric ton. If crab meal is added to fish meal, the retail value of the mixture decreases from that of fish meal, since protein content determines retail value. Crab meal contains approximately 30 percent protein compared to 60 percent protein in fish meal. The current market price is equivalent to $8.00 per metric ton per percent protein. Assuming this relationship holds true for a 54 percent protein fish-crab meal, a quarter metric ton of crab meal could be added to 1 metric ton of fish meal producing 1.25 metric tons at 54 percent protein for a value of $538. This would increase the effective crab meal value from $110 to $238 per metric ton. Thus, processing crab wastes mixed with fish meal might allow a positive economic recovery from the crab waste fraction.

Crab wastes produced at Akutan Harbor in 1982 are estimated at 1,200 metric tons. Meal recovery is approximately 20 percent, yielding about 242 metric tons of crab meal from this quantity of wastes. A 4:1 mixture would require 967 metric tons of fish meal or about 9 percent of the plant capacity. Some storage and remixing may be required to yield a suitable meal mixture depending on peak production of crab and fish.

Screening with Production of Fish Silage from Solids

The Trident plant would undertake the production of fish silage, a form of liquified fish wastes, using either acid preservation or fermentation methods. Fish silage can be used as a protein component in animal feed and has some advantages over fish meal. The process requires solids separation, mincing, storage, and transportation. Raa and Gildberg (1982) and Windsor and Barlow (1981) present detailed introductions to this process. Figure 3 from Windsor and Barlow (1981) presents a generalized diagram of a fish silage process. Processing wastes could be deposited into the storage unit prior to mincing or, during steady processing, could be added directly to the mincer. A de-oiling step is necessary for oily fish wastes. This process may not be necessary for cod wastes if the liver is separated from the waste stream prior to mincing.

This alternative was evaluated by Brown and Caldwell (1983) for Dutch Harbor, Alaska. It was concluded that fish silage could not be economically transported over 400 kilometers. Applying this same distance to Akutan would eliminate any market for the product. A fish silage facility at Akutan Harbor would produce approximately 25,500 metric tons annually at a current market value of $100 per metric ton (approximately 20 percent of the market value of an equivalent volume of fish meal). This value would not exceed the transportation costs to Seattle.

The capital costs for a fish silage production facility would be relatively small. The existing grinder at Trident could function as the mincer. Acid could be added during grinding to provide a well mixed solution. Storage units would be needed to allow for curing of the silage. This process ranges from 5 to 10 days for fresh white fish offal at 15°C (59°F). Heating the silage shortens this period but requires an energy source. Storage units must be acid resistant. Windsor and Barlow (1981) state that concrete tanks treated with bitumen are suitable for storing large quantities. A storage volume for 10 days of production at the Trident facility would be about 2,500 cubic meters. A tank 3 meters deep would cover 850 square meters of land.

Maintenance costs would also be low due to the simplicity of the system. Use of formic acid yields a superior product over other acids; approximately 3.5 percent by weight is required. This corresponds to roughly 900 metric tons annually. Purchase and transportation costs of this acid represent a major expense.

Advantages of this alternative include:

- removal of solids from marine environment.
- relatively simple process.
- low capital investment.

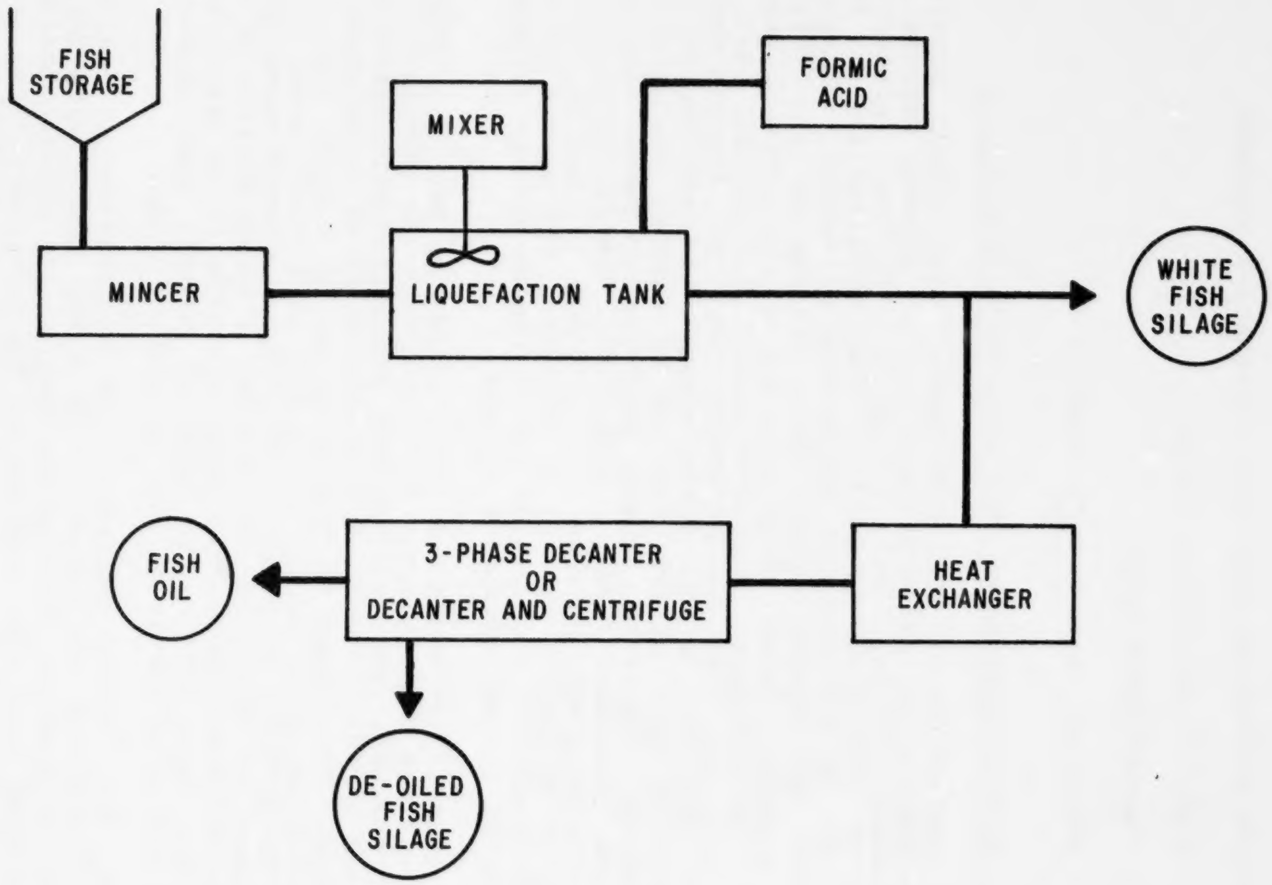
FISH STORAGE
MIXER
FORMIC ACID
MINCER
LIQUEFACTION TANK
WHITE FISH SILAGE
FISH OIL
3-PHASE DECANTER OR DECANTER AND CENTRIFUGE
HEAT EXCHANGER
DE-OILED FISH SILAGE

FIGURE 3. PROCESS DIAGRAM FOR FISH SILAGE PRODUCTION AND DE-OILING

SOURCE: WINDSOR AND BARLOW 1981

- marketable product.
- low energy consumption.

Disadvantages associated with this alternative include:

- high transportation costs.
- unestablished market.
- shellfish waste not utilized.

Screening with Production of Chitin/Chitosan from Solids

The conversion of shellfish wastes into chitin requires grinding, separating, acid demineralization, caustic deproteination, rinsing, drying, and transport. Chitosan production requires an additional processing step (deacetylation) that changes some of the chemical properties of chitin. Figure 4 from Hattis and Murray (1977) is a diagram of the Chitin/Chitosan process. After shell separation, the nonshell stream can be further processed to recover a shellfish protein meal. A protein meal can also be processed from the deproteination liquid slurry. The acidic waste stream from the demineralization step is high in salt and can be further processed for salt recovery. Therefore, several products can result from this alternative. Auerbach (1981) states that 1 ton (2,000 pounds or 910 kg) of shells will produce approximately 100 pounds (45 kg) of chitin or 80 pounds (36 kg) of chitosan, 200 pounds (91 kg) of protein meal, 300 pounds (136 kg) of impure calcium chloride, and 50 pounds (23 kg) of sodium acetate.

The quantity of shellfish waste at Akutan Harbor is highly variable and has significantly decreased from the 1980 high. As discussed earlier, crab waste solids averaged approximately 100 metric tons per day in 1980 with a 1982 daily waste of about 40 metric tons. This waste is only produced for a short period of time during the crab season but plant size would need to be based on daily waste production. Therefore, a large plant would be necessary but would not operate for a major portion of the year. Approximately 60 metric tons of chitin or 48 metric tons of chitosan, and 120 metric tons of protein meal would be produced from crab wastes at 1982 generation rates.

DPRA, Inc. (1980) evaluated the alternative of chitin/-chitosan production for Alaska. Two model plants were developed, one for Seattle, Washington, that would process shellfish meal generated in Alaska, and one on the east coast that would process raw crab wastes. A cost estimate is presented below based on DPRA (1980) data for the east coast plant. Capital costs have been increased by a construction cost factor of 3 to approximate the cost of building at Akutan.

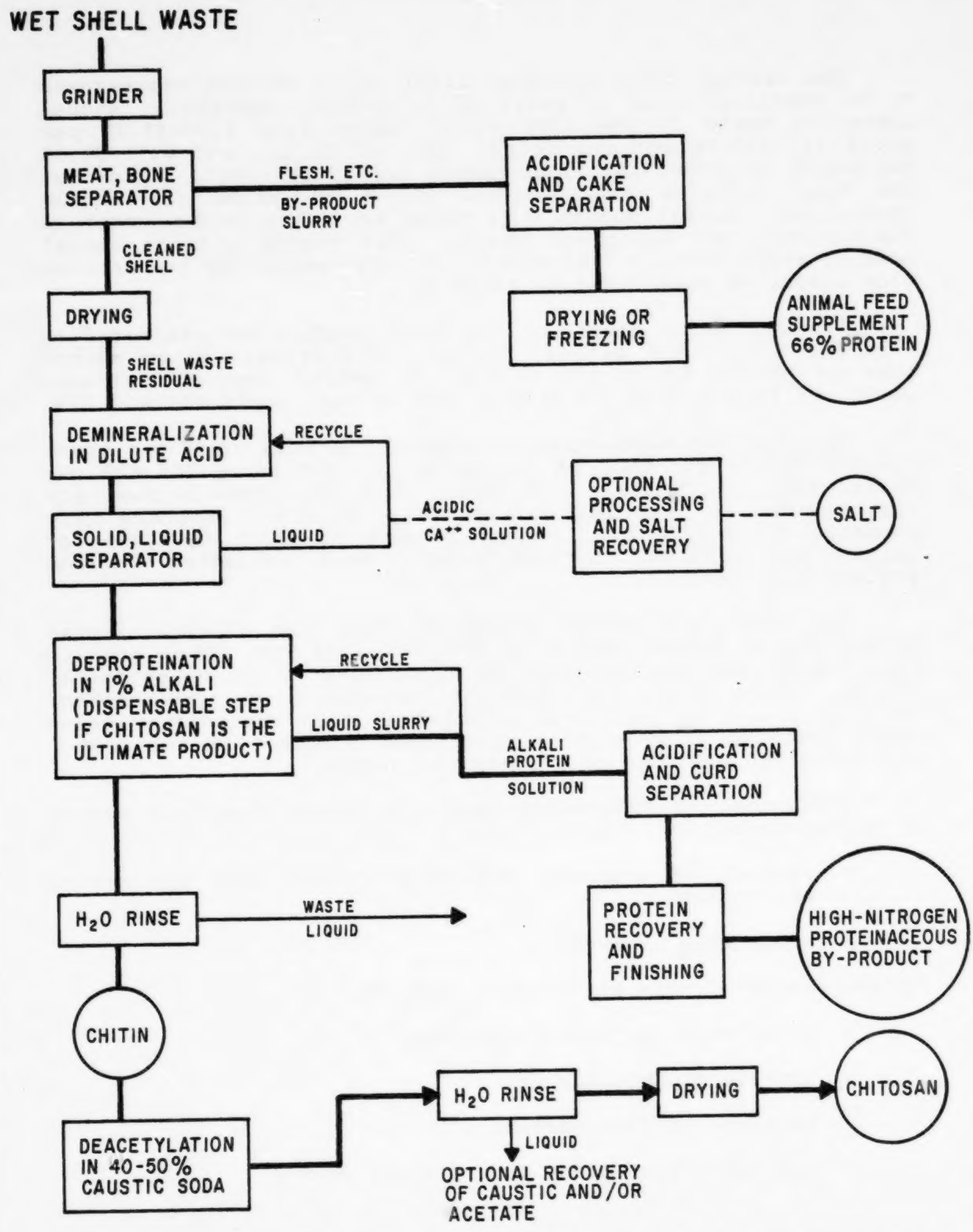
WET SHELL WASTE
GRINDER
MEAT, BONE SEPARATOR
FLESH. ETC.
BY-PRODUCT SLURRY
ACIDIFICATION AND CAKE SEPARATION
CLEANED SHELL
DRYING
DRYING OR FREEZING
ANIMAL FEED SUPPLEMENT 66% PROTEIN
SHELL WASTE RESIDUAL
DEMINERALIZATION IN DILUTE ACID
RECYCLE
ACIDIC
CA⁺⁺ SOLUTION
OPTIONAL PROCESSING AND SALT RECOVERY
SALT
SOLID, LIQUID SEPARATOR
LIQUID
DEPROTEINATION IN 1% ALKALI (DISPENSABLE STEP IF CHITOSAN IS THE ULTIMATE PRODUCT)
RECYCLE
LIQUID SLURRY
ALKALI PROTEIN SOLUTION
ACIDIFICATION AND CURD SEPARATION
H₂O RINSE
WASTE LIQUID
PROTEIN RECOVERY AND FINISHING
HIGH-NITROGEN PROTEINACEOUS BY-PRODUCT
CHITIN
DEACETYLATION IN 40-50% CAUSTIC SODA
H₂O RINSE
LIQUID
OPTIONAL RECOVERY OF CAUSTIC AND/OR ACETATE
DRYING
CHITOSAN

FIGURE 4. PROCESS DIAGRAM FOR CHITIN/CHITOSAN PRODUCTION

SOURCE: HATTIS AND MURRAY 1977

The capital costs (10-year life) at 14 percent are assumed to be amortized over 10 years at 14 percent interest. Annual operating costs in the DPRA study ranged from $.65-$1.17 per pound ($1,430-$2,580 per metric ton) of chitin and $.95-$2.10 per pound ($2,100-$4,630) per metric ton of chitosan. This cost has been inflated by a factor of 3 to allow for Akutan conditions. Annual maintenance costs are taken as 3 percent of the building and equipment costs. This yields a total annual cost of approximately $986,600-$1,106,600, excluding transportation costs, as summarized in Table 8.

Transportation costs for the final product are estimated at $110 per metric ton between Akutan and Seattle. Sixty metric tons of chitin would add $6,600, 48 metric tons of chitosan would add $5,300, and 120 metric tons of meal would add $13,200.

Revenues are also estimated using DPRA data of $2 per pound ($4,400 per metric ton) of chitin and $3 per pound ($6,600 per metric ton) of chitosan. Revenues from the protein meal are approximated at $478 per metric ton. No other revenues were assumed. This yields an annual revenue of about $321,400 for chitin and $374,200 for chitosan. Both estimates include protein meal revenues.

The resulting annual estimated loss for chitin/chitosan production at Akutan Harbor is $685,000-$750,900. This cost is approximate and should only be considered a rough estimate. Transportation from the floating processors to the chitin/chitosan plant has not been included in this analysis. Losses would decrease if more crab production occurred in the harbor and the plant was able to process the wastes.

Advantages of processing chitin/chitosan from crab wastes at Akutan Harbor include:

- o removal of seasonal shellfish wastes from the marine environment.
- o marketable product.

Disadvantages of this alternative include:

- o unproven commercial technology.
- o limited product market.
- o no reuse of fish wastes.
- o limited use of plant due to short season.

Screening with Recovery of Other Fish By-Products from Solids

Other technologies exist for the conversion of seafood processing wastes into usable products. These products include

Table 8. Cost Estimation for Chitin/Chitosan Process at Akutan Harbor[1]

		ANNUAL COSTS	
		CHITIN	CHITOSAN
Capital Costs			
Building	$ 825,000		
Equipment	2,000,000	$541,600	$541,600
	2,825,000		
Operation Costs			
Chitin 2.73/pound (6.00 per kg)		360,000	-
Chitosan 4.58/pound (10.00 per kg)		-	480,000
Maintenance Costs		85,000	85,000
Total Annual Production Costs		$986,600	$1,106,600
Transportation to Seattle		19,800	18,500
Total Annual Cost to Market		$1,006,400	$1,125,100
Projected Annual Revenues		321,400	374,200
Projected Annual Profit (Loss)		($685,000)	($750,900)

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[1] Based on data from Development Planning & Research Associates (1980) using 1977 dollars, inflated by a factor of 3 to represent Akutan cost. Interest at 14 percent amortization in 10 years.

Estimates exclude costs for screening of solids and delivery of solids to processing plant.

hydrolyzed fish products, fish protein concentrates, pet food, insulin, pearl essence, and fish glue. A brief discussion of each product is presented below.

Hydrolyzed fish products are produced by adding enzymes to the wastes and controlling the resulting breakdown. The end product, a fine powder, is soluble in water, unlike fish meal and fish protein concentrate. The waste is digested at 25-70°C for about 15 minutes. The liquid protein solution is then removed, leaving a solid waste consisting mostly of bones and skin. This waste would require additional handling for disposal or reuse. The liquid fraction is pasteurized and then dried. Oil removal may be necessary to prevent the product from having a fishy flavor.

This product process at Akutan would be similar to the fish meal process. Added costs would be incurred for the enzyme additive and additional solids disposal.

Fish protein concentrates are produced for human consumption. The process is essentially the same as fish meal production except that equipment must be fabricated from suitable material, i.e. stainless steel, that can be easily cleaned and sterilized. To yield a nonfishy product the oil content must be less than 1 percent. Solvent extraction is normally necessary to achieve this level, further complicating the process. A substantial marketing effort would be required for this product.

Seafood processing wastes can also be used for pet foods. Most products are canned, but some use of fish meal and wet wastes has occurred (Windsor and Barlow 1981). The production of pellet food for fish hatcheries has the advantage of an Alaskan market. The Seward and Petersburg plants have produced food for hatcheries.

Insulin, for diabetes treatment, can be extracted from fish viscera quite successfully. The process involves chemical fixation, extraction, and refining. The resulting insulin can easily be of high purity and concentration. The process, however, would not reduce the amount of solid wastes by a high percentage.

The same is true for the production of pearl essence. This substance is derived from fish scales and is used for imitation pearls and decorative lacquers. Several methods are available for extracting the essence.

Chapter 4

ENVIRONMENTAL AND INSTITUTIONAL SETTING

This chapter describes existing environmental conditions in Akutan Harbor and regulatory constraints that affect seafood waste handling options. The chapter sets forth the setting for evaluation of the alternatives. It also includes a discussion of seafood processing activities in the region and in Akutan; a discussion of potential markets for seafood processing by-products; and an evaluation of special constraints on industrial activities at Akutan.

Akutan Island

Akutan Island is one of the Krenitzen Islands within the Fox Island Group, part of the Aleutian Island chain of Alaska (Figure 1). Unalaska is 35 miles (56 km) to the west and Anchorage is approximately 800 air miles (1,280 km) to the northeast. The island is of volcanic origin and Akutan Volcano is active with the last eruption occurring in 1978. The island is about 18 by 12 miles (29 by 19 km) in size with rugged terrain. The treeless vegetation consists of arctic-alpine species and is concentrated below the 1,000-foot (300 meters) elevation. The climate is maritime, characterized by mild winters and summers with a mean temperature range between 25°F, (-4°C) and 56°F (13°C). Annual precipitation is estimated to be about 30 inches (760 cm) with snowfall occurring year-round except for September. Several small streams drain the island.

The island's only settlement, the City of Akutan, is located on the northern shore of Akutan Harbor, a sheltered inlet on the eastern side of the island. The village was established before 1900 and has a current population of about 100. The principal economic activity on the island is seafood processing carried out by floating vessels and the Trident shore-based plant. These processors support a transient population of up to 1,000 during peak production. Little interaction occurs between the villagers and the processing population, although several villagers are employed by the processors.

The village was incorporated in 1979 and has published a Comprehensive Plan (City of Akutan 1982). Public services provided include: education, public safety, phone service, health service, postal service, library, public recreation, and fire protection. Electricity is provided by a small hydroelectric system using a creek east of the village and some privately-owned diesel generators. A replacement diesel plant has recently become operational. The village water supply is obtained from another creek east of the village. A new sewage treatment system was recently installed that provided community septic tanks and an offshore discharge. Many of the villagers have recently occupied new housing units.

Akutan Harbor

Akutan Harbor is located on the eastern side of the island. The harbor opens up into Akutan Bay and is just north of Akun Strait. The harbor is relatively small, 4 miles (6.5 km) long with a width varying from 0.6 mile (0.9 km) to 2.3 miles (3.7 km), and is generally "U"-shaped in plan view and in cross section. Average water depth is greater than 100 feet (30 meters) and the maximum diurnal tidal range is approximately 4 feet (1.2 meters).

The harbor is the focal point of all transportation and shipping to the village. Amphibious aircraft and boats provide the only access to the village. Recreational use of the harbor is generally confined to boating, swimming, fishing, and hunting.

The sheltered nature of the harbor has encouraged several floating seafood processors (up to 13) and Trident Seafoods to establish processing bases within the harbor. The harbor and its environs provide shelter and processing waters (both salt and fresh) to the processors, and allows them to be close to the fishing grounds. No recreational use of the harbor by the temporal population is known. It is also unknown whether commercial harvesting of fish or shellfish occurs in the harbor.

The biological resources associated with the harbor are important elements of the cultural heritage of the native residents. A small pink salmon run occurs in a stream at the northwest corner of the harbor. Pink salmon, herring, Dolly Varden, and codfish have been harvested for subsistence, although codfish in the harbor are no longer used because of an increase in occurrence of parasitic worms in the muscle tissue. Clams are harvested from some areas in the harbor, and a few birds and marine mammals are also included in the subsistence harvest.

Water Quality and Sediment Quality

Water and sediment quality investigations of Akutan Harbor have been conducted in May 1978, May 1982, March 1983, June 1983, and September 1983. Detailed results of these investigations are presented in the following reports:

- Reconnaissance investigations of four floating crab processor waste disposal sites in Akutan Harbor, May 25-26, 1978. K. K. Imamura. Alaska Department of Environmental Conservation.
- Akutan Bay water quality analysis, Pre-preliminary draft. Alaska Department of Environmental Conservation. 1982.
- Biological and physical survey of Trident Seafoods waste discharge site in Akutan Harbor, Alaska. Evans Research Group, Inc. 1983.
- Effects of Seafood Waste Deposits on Water Quality and Benthos, Akutan Harbor, Alaska. Jones & Stokes Associates, Inc. 1983.

Water quality conclusions from these investigations are similar. No quality problems were observed and the water column was well mixed. It is necessary to keep in mind that processing levels were low at the time of all investigations and therefore may not reflect temporal water quality problems associated with major processing periods.

Flushing of the harbor is dominated by wind. This phenomenon is therefore difficult to assess accurately since the forcing mechanisms are erratic and resulting circulation patterns can be very complex. Based on drogue movements in June and September 1983, the residence time of the surface layer (10 meters and less) may generally be a few days, but may be a few weeks for deeper water. Again, it must be emphasized that circulation in Akutan Harbor, and therefore the residence time, will be highly variable because of the importance of wind on harbor circulation. Stratification of the water column, which could cause water quality problems, may occur during summer months, although the June and September surveys reported a well mixed water column.

Sediment character of the harbor reflects its protective environment, seasonal variations in plant life, and use for seafood processing. The outer harbor is subject to more scouring and dispersive actions than the inner harbor as evidenced by the grain size and large-scale sand waves. Total organic carbon (TOC) levels were found to vary seasonally and possibly reflect the accumulation of plant debris after the summer growing season. Sediment impacts from seafood processing include accumulation of processing wastes near those waste piles that are not easily dispersed, and elevated levels of hydrogen sulfide, ammonia, TOC, and organic nitrogen.

Biological Characteristics

Terrestrial Resources

Vegetation in the Akutan Harbor area is primarily moist tundra and alpine tundra/barren ground (Crayton 1983). Commonly occurring vascular plants include lupine, cow parsnip, monks hood, orchids, Indian paint brush, chocolate lily, numerous types of asters, wild geranium, ferns, and several species of grasses. A large wetland habitat is located at the head of Akutan Harbor and a smaller wetland area is located near the south shoreline across the bay from the town of Akutan.

The red fox (*Vulpes fulva*) is one of the few terrestrial mammals inhabiting the island (Crayton 1983). At one time, a small cattle ranch operated near the head of Akutan Harbor.

Freshwater and Marine Resources

The freshwater stream at the head of Akutan Harbor is cataloged by Alaska Department of Fish and Game (ADF&G) as an anadromous fish stream (Sundberg pers. comm.). The stream is small (approximately 20 cfs in June) and highly sinuous. In August 1982, 10,500 adult pink salmon were observed in the stream. Fewer pink salmon are expected during odd-numbered years. Coho salmon and Dolly Varden are also reported to spawn in the stream. Based on pre-emergence studies in the Shumagin Islands, pink salmon fry probably begin to emerge from the gravel and enter the estuary in early April. Although the stream is a relatively minor producer of salmon, it apparently is important for local sport and subsistence use.

The intertidal zone in Akutan Harbor is a relatively narrow band of marine habitat influenced by a tidal range of 1.2 meters (3.9 feet, mean lower low water to mean higher high water) (National Ocean Survey 1983). The substrate of the upper intertidal zone is generally cobble/boulder mixed with gravel except for the rock/bedrock substrate near Akutan Point. The upper zone is dominated by barnacles (*Balanus* spp.), limpets (*Acmaea* spp.), blue mussels (*Mytilus edulis*), rockweed (*Fucus* sp.), and sea lettuce (*Ulva/Monostroma*) (Crayton 1983). The middle intertidal zone is covered by a brown alga (*Laminaria* sp.) and/or sea colander (*Agarum cribrosum*). Beneath the canopy of algae is a sandy/gravel substrate with scattered aggregates of boulders. Nuttall's cockle (*Clinocardium nutallii*), a soft shelled clam (*Mya truncata*), and hermit crabs (*Pagurus* spp.; *Elassochirus* spp.) are common in the middle zone. The substrate of the lower intertidal zone is more silty, and is inhabited by seastars (*Pycnopodia helianthoides*, *Evasterias troschelli*), and an anemone (*Metridium senile*). Factors that influence the species composition of the intertidal zones include the degree of wave shock, substrate composition, and tidal exposure.

The subtidal habitat of Akutan Harbor is characterized by a steep slope along the harbor perimeter and a relatively flat, soft bottom throughout most of the harbor. Four benthic communities have been identified: a community occupying fine (silt/clay) sediments in the inner harbor; a community occupying fine sand in the outer harbor; a sand dollar community occupying uniform fine sands along the south (exposed) shore of the outer harbor; and a kelp community located in a shallow rock/bedrock area south of Akutan Point and along the south shore of the outer harbor (Jones & Stokes Associates 1983; Crayton 1983).

Although overlap in species composition occurs between the four communities, differences occur in the dominant species of each community. Polychaetes (*Ninoe simpla*; *Boccardia polybranchia*) are the numerically dominant taxonomic group of the inner harbor, whereas bivalves (either *Macoma moesta* or *Axinopsida orbiculata*) tend to be more abundant than polychaetes in the outer harbor (Jones & Stokes Associates 1983). The sand dollar community is unique to Akutan Harbor in that sand dollars (*Echinarachnius parma*) and crustaceans (Amphipoda) were abundant here, and few polychaete species were present. Dominant epibenthic species of the rocky subtidal community include kelp (*Alaria* spp.), sea urchins (*Strongylocentrotus droebachiensis*), seastars (*Henricia leviuscula*; *Leptasterias hexactis*, anemones (*M. senile*; *Tealia crassicornis*; *Anthopleura artemisia*), and hermit crabs (*Pagurus* spp.; *Elassochirus* spp.) (Crayton 1983).

Commercially important Tanner crab (*Chionoecetes bairdi*) were observed by underwater video camera to be abundant during the June and September 1983 field survey. As noted elsewhere in the southeast Bering Sea, Tanner crab may play an important role in the food web of the harbor (Jewett and Feder 1981), as well as providing an important fishery resource. A pod of juvenile king crab (*Paralithodes camtschatica*) were observed in the harbor during July 1983 (Crayton 1983). King crab may be abundant seasonally as king crab are believed to utilize coastal embayments for spawning and rearing (NOAA unpubl.). Akutan Harbor is at the western margin of known major crab fishing grounds.

Sampling of fishes in Akutan Harbor is limited to the shallow littoral zone. During July 1983 juvenile pink salmon (*Oncorhynchus gorbuscha*) and sand lance (*Ammodytes hexapterus*), an important forage species, were the major species captured in beach seines (Crayton 1983). Other fishes included coho salmon (*O. kisutch*), Pacific tomcod (*Microgadus proximus*), flatfishes (*Pleuronectidae*), sculpin (Cottidae), and Dolly Varden (*Salvelinus malma*). In the deeper, soft bottom areas of the harbor, daubed shanny (*Lumpenus maculatus*) were observed by underwater video camera to be abundant. Based on subsistence harvests, it is known that herring (*Clupea harengus pallasi*) and Pacific cod (*Gadus macrocephalus*) inhabit the harbor area (Gross pers. comm.).

The most numerous and readily observed wildlife resources in the Aleutian archipelago are birds, especially pelagic bird species. No major nesting colonies are located along the shore of Akutan Harbor, but a major black-legged kittiwake (*Rissa tridactyla*) colony occurs along the northeast shore of Akun Island, and a large tufted puffin (*Lunda cirrhata*) colony occurs south of Akun Strait on Rootok Island (Sowls et al. 1978). The so-called "North Island" of Akun Strait has a high density nesting colony of tufted puffin (Nysewander et al. 1982). This islet is 8 km due east of Akutan Harbor and was occupied by approximately 41,000 tufted puffin burrows in 1980.

On Akutan Island, the largest nesting colonies occur on the north and west shores, and are comprised primarily of cormorants (*Phalacrocorax* spp.). The largest nesting colony near Akutan Harbor is on Akutan Point. This colony was occupied by approximately 322 cormorant nests and 2,000 tufted puffin burrows (Nysewander et al. 1982). Waterfowl and shorebirds are also likely to be abundant in Akutan Harbor. Bald eagles (*Haliaeetus leucocephalus*) are common throughout the harbor and reportedly nest near Akutan Point (Crayton 1983).

Marine mammals in Akutan Harbor are primarily harbor seals (*Phoca vitulina richardii*), sea lions (*Eumetopias jubatus*), and sea otters (*Enhydra lutris*) (COE 1982; Gross pers. comm.). Sea lion haul-out areas near Akutan Harbor include: an islet off the north shore of Rootok Island, Akun Head on the north shore of Akun Island, North Head, Reef Bight to Lava Point, and Cape Morgan on Akutan Island (Figure 1). Sea otters occur in the kelp beds at the mouth of the harbor and along Akun Strait (COE 1982; Nysewander et al. 1983; Gross pers. comm.). Whales and dolphins may occasionally be sighted in coastal waters and in Akun Strait.

Recreational and Subsistence Harvests

Recreational fishing in Akutan Harbor is probably minor and limited to commercial fishermen staying in the harbor and seasonal workers at the seafood processing plants. Dolly Varden, salmon, flatfishes, sculpin, and Pacific cod are the fishes most likely to be harvested.

Although the Akutan community is based on a cash economy, subsistence harvests are important as a cultural and supplementary resource. Subsistence harvests of fish in or near the harbor include sockeye salmon, which are migrating through the island waters, and pink salmon returning to spawn in Akutan Island creeks (Gross pers. comm.). Other harvested fishes include Pacific cod, sculpin, herring, and small halibut. Fewer Pacific cod are presently taken because of an increase in nematodes in the flesh of locally caught cod. Clams and sea urchins (sea eggs) are harvested along the shoreline of the inner harbor. The clam population has declined and is periodically tainted with diesel oil flavor (Stepetin pers. comm.; McGlashan pers. comm.). Tainting of clam flesh may be caused by fuel residues, oil, or discharges from boat traffic. Other subsistence harvests include birds (e.g., puffins, golden eyes and scaups) and an occasional marine mammal (e.g., sea lions, seals, and sea otters).

Commercial Seafood Harvest and Processing

Regional Overview

Much of the finfish and shellfish harvested domestically in Alaskan waters of the eastern Bering Sea and the Aleutian Islands area is processed at three ports located in the Aleutian Island chain. Two of the ports, Dutch Harbor and Akutan Harbor, are centrally located in the Aleutian chain, whereas the third port, Sand Point, is located 275 miles (440 km) east of Dutch Harbor.

By far the largest of the Aleutian ports, Dutch Harbor is one of the largest (in terms of the dollar value of fish sales) harvesting and processing port communities in the U.S. Four on-shore processing plants and 13 permanently moored processing vessels operate in the Dutch Harbor area (Centaur Associates 1982). By comparison, processing facilities at Akutan Harbor and Sand Point are much smaller. The distance from Sand Point to the resource-rich fishing grounds of the Bering Sea limits its use as a processing port. Secondary services such as layover accommodations and minor vessel repairs are provided at Sand Point.

In addition to port processing facilities, much of the fishery resources harvested in more distant waters of the Bering Sea are processed at sea. Through joint ventures, U.S. harvesters and foreign processors utilize catcher/processing vessels at distant fishing grounds.

Important fishery resources processed domestically at Aleutian ports include crab, shrimp, salmon, cod, perch, pollock, herring, and other groundfish. In general, groundfish, which are processed into both blocks and fillets, are shipped for domestic consumption. Shellfish, primarily crab, are processed mainly in sections and are supplied to foreign as well as domestic markets.

Seafood Processing at Akutan Harbor

Akutan Harbor, which is located approximately 35 miles (56 km) east of Dutch Harbor, provides permanent and seasonal seafood processing facilities. Two shore-based processing vessels operate out of Akutan year-round. In addition, as many as 13 floating processors operated in the harbor during the 1980 and 1981 crab seasons. According to one recent study (Centaur Associates 1982), the number of seasonal floating processors operating in Akutan Harbor depends on the volume of seafood being harvested in the region because during peak harvest years much of the seasonal processing at Akutan is overflow activity from Dutch Harbor.

The land-based Trident Seafood processing plant, constructed in 1982, was destroyed by fire in June 1983. The owners plan to rebuild. The plant was primarily a cod processing plant, with a maximum seafood processing capacity of 600,000 pounds (272 metric tons) per day. Products were mainly salted split cod and salted cod fillets, although crab and other shellfish were brined, frozen, and packed as sections. Herring, salmon, and other species of bottomfish also were processed, but in smaller quantities.

As of March 1983, the Trident plant had processed approximately 9.1 million pounds (2,760 metric tons) of finished codfish products and 1.4 million pounds (600 metric tons) of other seafood products including crab, salmon, and herring (Soderlund pers. comm.). Most Pacific cod processed at Akutan was harvested locally, near Unalaska and Akutan Islands (Blackburn pers. comm.). Herring is brought to Akutan Harbor from locations as far as Togiak (Bristol Bay) and Prince William Sound, whereas salmon processed at Akutan are harvested within a two-day boat run of Akutan Harbor (Cloe pers. comm.). The several species of king and Tanner crab processed at Akutan Harbor are harvested throughout the Bering Sea and Aleutian Islands (Cloe pers. comm.; Eaton pers. comm.).

With the reconstruction of the Trident Seafood processing plant, future processing activity in Akutan Harbor is likely to include both seasonal and year-round processing facilities. The extent of future processing activity will depend on market conditions, some of which are discussed below.

Bottomfish Resources

As shown on Table 9, the domestic harvest of bottomfish in the Eastern Bering Sea/Aleutian Island region has developed only recently. Prior to 1980, bottomfish (which includes cod, flounder, pollock, sablefish, rockfish, and others) were harvested in significant numbers only by foreign fishermen. In 1980, 38,800 metric tons were harvested domestically, representing approximately 3 percent of the estimated harvest by foreign fleets. (U.S. Army Corps of Engineers 1982). In 1981, the domestic harvest of bottomfish increased to 87,300 metric tons. The 1981 harvest, although a significant increase over 1980 levels, was still only a small percentage of the foreign harvest

Table 9. Domestic Catch Statistics (Metric Tons) for Fish and Shellfish that are Potentially Available to Akutan Harbor Seafood Processors, 1974 - 1982.

	YEAR								
	74	75	76	77	78	79	80	81	82
FINFISH (Eastern Bering Sea and Aleutian Island Areas)									
Pollock	NF	NF	NF	NF	NF	NF	NF	41,937	ND
Flounder	NF	NF	NF	NF	NF	NF	NF	21,990	ND
Pacific Cod	NF	NF	NF	NF	NF	NF	NF	18,048	ND
Atka Mackerel	NF	NF	NF	NF	NF	NF	NF	1,633	ND
Sablefish	NF	NF	NF	NF	NF	NF	NF	180	ND
Rockfish	NF	NF	NF	NF	NF	NF	NF	8	ND
Ocean Perch	NF	NF	NF	NF	NF	NF	NF	2	ND
Other	NF	NF	NF	NF	NF	NF	NF	3,538	ND
Total	NF	NF	NF	NF	NF	NF	38,800	87,336	ND
Herring (Sac roe, food, bait)									
Western Region (ADF&G)	37	51	0	2,550	7,061	9,128	21,123	3,538[a]	ND
Central Region (ADF&G)	9,039	9,310	6,761	5,333	3,513	6,723	10,580	25,458[a]	ND
Salmon (Alaska Peninsula, Chignik, Aleutian Islands)	4,398	3,512	14,648	15,959	24,133	31,335	40,509	43,494	ND
SHELLFISH (Aleutian Islands, Bering Sea, Bristol Bay)									
King Crab	28,413	30,693	37,392	37,273	47,453	60,182	74,545	26,227	12,455
Tanner Crab	2,552	3,231	22,938	24,172	32,133	34,955	35,182	37,818	19,000
Korean Hair Crab	NF	NF	NF	NF	NF	24	1,091	409	ND
Shrimp	2,613	406	1,668	2,091	3,028	1,455	1,091	955	136

NF - No fishery, except for bait fishery.

ND - Data not available.

[a] - Bristol Bay District managed under the Central Region after 1980.

SOURCES: U. S. Army Corps of Engineers 1982, Alaska Department of Fish and Game.

and significantly below the Northern Pacific Fishery Management Council allocation for domestic annual harvests (DAH). The 1982 DAH for bottomfish in the eastern Bering Sea/Aleutian Islands area was 189,300 metric tons or 12 percent of the total optimum yield for the area.

It should be noted that of the 87,300 metric tons of bottomfish harvested domestically in the eastern Bering Sea/-Aleutian Islands area in 1981, only 11 percent was delivered to U.S. processors. Pacific cod represented over 95 percent of these deliveries (U.S. Army Corps of Engineers 1982). The remaining domestic catch was delivered to foreign processors through joint venture arrangements.

The potential for expansion of the domestic bottomfish fishery appears good, even though an unusually large year class of Pacific cod in the eastern Bering Sea/Aleutian Islands area is experiencing a natural decline (Blackburn pers. comm.). According to one recent study (U.S. Army Corps of Engineers 1982), an estimated 200,000 metric tons could be harvested annually by a fleet of vessels operating from Akutan Harbor.

Salmon and Herring Resources

Other finfish important to Akutan seafood processors are salmon and herring. As shown in Table 9, salmon harvests have increased significantly in recent years primarily due to greater abundance. Many of the salmon harvested in the Aleutian Islands passages are returning to spawning grounds near Bristol Bay. The present condition of salmon stocks is considered strong (Rogers pers. comm.)

In terms of volume (Table 9), herring has developed into an important fishery in the region in recent years. Although considered a relatively low value fish, herring processed at Akutan Harbor has been brought from locations as far away as Togiak (Bristol Bay) and Prince William Sound. Recent increases in the herring harvest are a result of a greater fishing effort in the Togiak region. Potential herring fishing areas also exist in the Aleutian Islands and along the south side of the Alaska Peninsula; the size and condition of these stocks, however, are unknown.

Shellfish Resources

As shown in Table 9, domestic harvests of shellfish have declined considerably since the peak harvest years of 1978 and 1979. In 1982, shellfish harvests were only 30 to 40 percent of the peak harvest years. All shellfish stocks are presently depressed with the exception of one species of Tanner Crab (*Chinocetes opilio*), which is considered stable (Eaton pers. comm.). The decline in the shellfish fishery may be caused by increased predation or disease, warmer water temperatures, and overfishing (Otto et al. 1983). The future availability of shellfish is uncertain.

Seafood Demand Conditions

Future demand for shellfish and fish products processed at Akutan Harbor will be determined by developments in U.S. and foreign markets. Shellfish products processed at Akutan are currently shipped to both foreign and domestic markets. Domestic consumption of shellfish products is primarily in restaurants, whose sales tend to mirror overall economic conditions. During the most recent economic downturn, demand for shellfish products was steady, even while prices increased due to supply reductions (Centaur Associates 1982). Based on per capita consumption of and market demand for shellfish products in recent years, future demand can be expected to remain strong.

Potential markets for bottomfish processed at Akutan, however, are somewhat less certain. At present, nearly all domestically processed bottomfish are delivered to U.S. markets (Centaur Associates 1982). Domestic markets, which consist of primarily retail stores and restaurants and, to a lesser extent, institutions, are shipped mostly frozen fillets (U.S. Army Corps of Engineers 1982). High domestic processing costs enable foreign processors to capture a major share of the U.S. market. These higher domestic processing costs, in conjunction with tariffs, quotas, and other less formal restrictions, also limit U.S. entry into foreign markets.

Resource Outlook

The proximity of Akutan to the resource rich waters of the eastern Bering Sea and Bering Islands area should provide considerable opportunities in the future to processors in Akutan Harbor. Shellfish and salmon harvests should continue to generate seasonal demand for processing. If currently low stocks of shellfish persist, seasonal activity on floating processors in the harbor will be limited.

In the future, U.S. vessels are expected to harvest an increasing share of bottomfish resources in the eastern Bering Sea and Aleutian Islands area. The extent to which domestic processing activity will also increase is less certain. To some extent, fishing restrictions and catch quotas on some major importers are likely to reduce inventories available for U.S. buyers. Also, increased demand for bottomfish products in other countries likely will further limit supplies available to U.S. buyers (U.S. Army Corps of Engineers 1982).

If these effects, however, do not sufficiently increase domestic processors' share of the U.S. market, it would appear that foreign markets such as in Japan, other Asian countries, and Europe will need to be developed; otherwise, U.S. participation in the bottomfish processing industry may continue, primarily as joint ventures between U.S. harvesters and foreign processors (Centaur Associates 1982).

Fishery resource fluctuations could have an influence on the success of a fish reduction facility. Factors such as resource depletion, variable harvest levels associated with market demand, exposure to natural hazards, and the premium commanded by capital suppliers in light of these risks may all affect the economics of such a facility. Reductions in bottomfish resources of the Bering Sea and Gulf of Alaska would not likely affect domestic bottomfish harvests because of tremendous fish biomass relative to domestic harvests and domestic processing capabilities. Presently, most domestic fishermen sell their bottomfish catch to foreign processors because of the lack of domestic processors (Morris et al. 1983). The effect of variable harvests is anticipated to have less impact on a fish meal venture due to the flexibility of the process to handle different species as whole fish or fish processing wastes.

Markets for Seafood Processing By-Products

Several of the alternatives introduced in Chapter 3 include the processing of seafood waste to recover usable by-products. Market conditions for such by-products are an important factor in evaluating the practicality of seafood waste reduction and by-product reuse.

The market feasibility of seafood waste reduction in Alaska has been the focus of several studies in recent years (Edward C. Jordan 1979; Development Planning and Research Associates [DPRA] 1980; DPRA 1980a). In general, the lack of local markets and the remoteness from major domestic markets significantly limit the marketing potential of seafood processing wastes from Alaska. Production and marketing costs reflect high capital, labor, energy, and transportation costs.

As described in the Alternatives chapter, important products recoverable from seafood processing wastes include: 1) fish meal and oil; 2) fish silage; 3) other fish by-products; and 4) chitin. In this chapter, potential uses of and markets for these products are examined.

Fish Meal and Oil

Fish and shellfish processing wastes can be dried and ground into fish meal. This process involves separation of fish oil, which is also a marketable product. Fish meal and, to a lesser extent, oil are valued primarily for their protein value, although other characteristics such as sulfur amino acid, lysine, and methionine are important in product marketing.

The principal uses of fish meal are as an ingredient in high protein feed for broilers, swine, and hatchery fish. Other ingredients used in high protein animal feeds include tankage and meat meals and dried milk products. Most fish meal is produced from plants designed solely for fish reduction, although seafood processing wastes and fishery by-catches are also important sources. In recent years, one species, menhaden, has accounted for most U. S. fish meal and oil production. In 1982, 81 percent of the total U. S. production of fish meal and over 97 percent of the U. S. production of fish oil were derived from menhaden. The availability of menhaden is the primary reason for its market dominance. Tuna and mackerel accounted for about 10 percent of domestic fish meal production in 1982. The high phosphorous content of tuna fish meal is a desirable product characteristic.

Between 1978 and 1982, annual U. S. production of fish meal averaged approximately 325,000 metric tons (NMFS 1983). During the same period, fish meal imports averaged approximately 59,000 metric tons and fish meal exports averaged about 41,000 metric tons annually. Domestic production of fish oil is primarily shipped to foreign markets, with over 80 percent of U.S. production being exported between 1978 and 1982. In 1982, three states, Louisiana, Virginia, and Maine accounted for 70 percent of the total value of domestically produced industrial fishery products (NMFS 1983).

As of 1980, three reduction plants were operating in Alaska. These plants, located in Petersburg, Seward, and Kodiak, use primarily seafood processing wastes as raw materials. Major reduction products from these plants include salmon meal, herring meal, oil, and low-value crab and shrimp meal. In 1978, these plants accounted for less than 2 percent of total U.S. production of fish meal. It has been estimated that if all seafood processing wastes in Alaska were processed, Alaska could account for nearly 10 percent of U.S. production of fish meal (DPRA 1980).

Alaskan fish meal is supplied primarily to markets in the Pacific Northwest via Seattle and, to a much lesser extent, to local Alaskan markets. Markets in the Pacific Northwest include a small but growing broiler industry in Washington and Oregon and a fish hatchery industry in Washington, Oregon, Idaho, and Utah. In 1977, approximately one-half of 1 percent of the total U. S. broiler production occurred in Washington (DPRA 1980)

The Alaskan market, consisting primarily of fish hatcheries with practically no broiler placements, is limited. Alaska's small population and the importation of about 95 percent of its food products considerably limits the market potential for fish meal (Shepherd pers. comm.). At present, one fish meal producer, Icicle Seafoods, supplies the entire local market needs. Although new fish meal producers in Alaska likely would try to capture some portion of the local market, the market potential is very small.

An additional market available to Alaskan fish meal producers is the Far East, including Japan, Hong Kong, Taiwan, and the Philippines. To date, only a few shipments of fish meal have been made to this area. With significant increases in Alaskan fish meal production, however, this market would warrant further consideration.

Demand for fish meal is strongly influenced by broiler placements, prices of competing products, and fish meal prices (DPRA 1980). In general, as red meat prices increase, broiler production and the demand for fish meal also increase. The demand for Alaskan fish meal, however, is affected generally by only significant price changes (DPRA 1980).

The price of fish meal and oil produced in Alaska closely follows world prices of menhaden meal and oil and the price of soybean substitutes. Although fish meal prices varied considerably during most of the 1970s (from a high of $527 per metric ton in 1973 to a low of $270 per metric ton in 1975), prices have remained relatively stable since 1978. As shown in Chapter 3, the current price of fish meal with a 60 percent protein content is $478 per metric ton (FOB Seattle). This price is historically higher and reflects recent supply shortages caused by the El Nino effect. Fisheries off the coasts of Peru and Chile have not been productive over the last 2 years. In addition, production from the Southern California anchovy fishery has been disappointing (Deardoff pers. comm.). These two occurrences have resulted in recent supply shortages and higher prices for fish meal.

At the current price, most Alaskan fish meal is being sold to fish hatcheries which can pay more for the product. According to one market analyst (Deardoff pers. comm.), however, the peak of the market appears to be near so that fish meal products should begin coming into the market at cheaper prices.

The current price for fish oil is about $396 per metric ton with market demand considered nominal. The current price for shellfish meal is about $110 per metric ton with market demand considered weak (Shepherd pers. comm.).

In one study, (DPRA 1980) of the market feasibility of seafood waste reduction in Alaska, reduction plants were found to be uneconomical at most locations when compared with barging alternatives. Reduction was cost effective at three locations - Kodiak, Seward, and Petersburg. These reduction plants are currently all in operation, although the Kodiak plant has had financial difficulties and ownership has been transferred to the City of Kodiak for operation. In the Dutch Harbor/Unalaska area, the high cost to transport reduction products to Seattle markets has been an important constraint to economic feasibility. In 1978, carrier rates between Dutch Harbor and Seattle for transport of ground fish meal packaged in bags (40,000-pound or 18-metric-ton minimum) were $4.16 per 100 pounds (45 kilograms) plus terminal charges (DPRA 1980). As shown in Chapter 3, the most recent (November 1983) rate to transport ground fish meal in bags (44,000-pound or 20-metric-ton minimum) between Dutch Harbor and Seattle was $3.68 per 100 pounds ($95.25 per metric ton) plus terminal charges (Petersen pers. comm.). This net reduction in carrier rates between Dutch Harbor and Seattle is explained by unique competitive conditions for this particular route.

In conclusion, the type, volume, and seasonality of processing wastes, and the utilization of plant capacity will influence significantly the economic viability of seafood waste reduction in Akutan. The decrease since 1978 in transportation costs for fish meal improves the competitive position of Alaskan producers. Steady growth in poultry markets will help maintain fish meal demand. According to one analyst of fish meal markets (Shepherd pers. comm.), the price outlook for fish meal is for steady but rising prices in the foreseeable future. With no significant increases in production anticipated, the market has been described as "workable". Primary market opportunities likely will be in the Pacific Northwest although the Far East could provide some market potential.

Fish Silage

Fish silage is a liquified fish product consisting of ground raw fish or fish waste in an acid solution. Similar to fish meal, fish silage is valued primarily for its high protein content. The production of fish silage does not require the high cost of drying fish waste which is characteristic of fish meal production.

With a nutritive content similar to fish meal, the primary use of fish silage is as an animal feed. Experiments with fish silage as a feed are limited. One study, however, concluded that fish silage is not very suitable for poultry feeds but showed favorable results with pigs, (Raa and Goldberg 1982).

The lack of local markets is a severe limitation to the marketing potential of fish silage. Because of the high liquid content, fish silage is four or five times as bulky as fish meal per unit of protein content. Consequently, costs to transport fish silage to markets are substantial. One study (Brown and Caldwell 1983) recently concluded that fish silage could not be economically transported over approximately 260 miles (400 kilometers) even under conditions of 100 percent plant capacity utilization.

In addition to high transport costs, the marketing of fish silage faces other barriers. It is not a well known commodity to potential users; as a result, a considerable marketing effort would be required to familiarize users with the potential advantages of the product. Also, other characteristics of the product, such as storage requirements and odor problems, would likely impede market acceptance.

Chitin

Chitin, and its derivative, chitosan, is a natural polymer derived from shellfish wastes. The production of chitin is currently in the pilot plant stage of development. The variety of potential applications of chitin, however, makes commercial production possible in the near future.

One of the most promising uses of chitin is as a coagulant. Chitin has been used in Japan in the coagulation of sludge in sewage treatment plants. Chitin is used as a less expensive substitute for alum. Other potential coagulant uses include application to food wastes to produce a feed product (Brown and Caldwell 1983).

Other promising uses of chitin and chitosan include film forming, animal feed, metals removal at waste treatment plants, cement production, and as a waterproofing agent. Industries which potentially could use chitin products include the medical, manufacturing, food processing, agriculture, and waste treatment industries.

In the past, chitin production was assumed to be dependent on "fresh shells"; recent efforts at a pilot plant in Oregon, however, have produced high quality chitosan using dried, coarse-ground crabshell meal shipped from Kodiak, Alaska (Brown and Caldwell 1983). This development has important market implications to the use of Alaskan shells for chitin since high construction costs, shipping costs (for chemicals needed to process chitin), and plant operating costs effectively preclude development of a chitin plant in Alaska at this time.

Other Fish By-Products

Other potential products from seafood processing wastes include hydrolyzed fish products, fish protein concentrates, pet food, insulin, pearl essence, and fish glue. Markets for insulin and pearl essence produced from seafood wastes are currently small, and because waste reduction would be minimal, reuse opportunities are not considered significant. For fish glue production, a once healthy industry has declined in recent years with the advent of new adhesives, many of which provide desirable characteristics that are lacking in liquid fish glue.

Consequently, the fish glue industry is no longer considered an economically important industry (Windsor and Barlow 1981).

Hydrolyzed fish products are powdery fish protein substances with variable concentrations of available protein. Certain hydrolyzed fish protein products are of considerable interest because of their water solubility. Although hydrolyzed fish products have been manufactured from all types of fish, production from lean fish is generally desirable.

Most commercial interest in hydrolyzed fish products is as a milk substitute. Fish protein can be used as a less expensive substitute to milk protein from animals for feeding their young. Hydrolyzed fish products also may be used in pet foods.

In contrast to hydrolyzed fish products, fish protein concentrate (FPC) is produced for human consumption. Extracted by a chemical process to produce a white, odorless substance, FPC is generally over 90 percent protein and is used as a food additive. Although certain restriction to its use exist in the U.S., a number of products containing FPC have been made experimentally, including staples such as bread, pasta, breakfast cereals, and dietetic foods. Significant potential market opportunities exist in less developed countries where diets are typically protein deficient. Production of FPC from seafood processing wastes appears best suited for manufacturing in conjunction with a waste reduction or chitin production plant.

Constraints on Implementation

When evaluating the alternatives it is necessary to consider special circumstances imposed by the remoteness of Akutan. The island's distance from centers of commerce adds several constraints to industrial activities that are not always present in the lower 48 states. These constraints include:

- lack of ground for facilities.
- distance from any market except for possible bait.
- lack of energy source.
- cold, wet weather conditions.
- limited fresh water supply.
- high cost for materials.
- lack of skilled personnel.
- high turnover rate for personnel.
- high labor costs.

The harbor is bounded by steep hills on the majority of its perimeter. The valley at the head of the harbor offers some room for expansion. The Native Corporation and State of Alaska own a large percentage of the valley lands. The Trident facility was constructed partly on fill and will have extra space available when use of the drying racks is discontinued (Cloe pers. comm.). Other areas which may be available are the old whaling station, a storage area, and the two coves at the mouth of the harbor.

Akutan Island is located in a very remote and unpopulated area. Markets for seafood by-products are significant distances away, escalating transportation costs to and from the island. The potential market for bait products does exist due to the proximity of the fishing grounds.

Energy production is currently limited to diesel generators and a small hydroelectric facility serving the City of Akutan. Additional hydroelectric power is restricted to small plants that could utilize the streams around the harbor. This power potential is very small and is not dependable during summer months. Essentially all energy needs must be met by imported fuel and local generation.

Weather conditions are cold and wet almost year-round. This complicates processes that are temperature-dependent such as digestion. Long winter nights and snow also add to the difficulties.

Freshwater inflow to Akutan Harbor from all tributary streams was estimated in June 1983 as 64 cfs and, while not quantified during the September investigation, was judged by observation to be less at that time. This flux of fresh water is divided between several small streams around the harbor. The largest stream is at the head of the harbor and was discharging 27 cfs in June. The groundwater resources of the island are not known but are not expected to be large based on island size and topography.

The high cost of materials of Akutan Harbor reflects the distance from major manufacturing and distribution centers. Items must be obtained at Dutch Harbor, Cold Bay, Anchorage or from the lower 48 and shipped by air or sea to Akutan at considerable expense. Delays in forwarding by commercial carriers are common. Capital costs and operation and maintenance costs are directly increased by the cost of materials and by the need to provide extra reliability, redundancy, and replacement parts on-site.

Many of the above factors contribute to difficult labor conditions for both employer and employee. Lack of normal urban culture, restrictive weather, confined working and living areas, and other factors lead to high turnover. The local population is small and has not been significantly employed by the processors in the past. Personnel are mainly recruited from population centers elsewhere in Alaska or in Seattle and transported to the harbor. A typical employment contract lasts 4-6 months, which results in a continual flux in the force. Training is an ongoing process and the availability of skilled labor is limited by high turnover. Room and board must also be provided by the processors.

Regulatory Constraints

Federal and state regulations have been developed which apply to the disposal of seafood wastes in Alaska. At Akutan Harbor, seafood wastes could be discharged into the marine environment, discharged as solid waste into a sanitary landfill, or incinerated. Accordingly, disposal regulations differ for each method; however, in general, state regulations are supplemental to federal regulations. Local regulations have not been established at Akutan Harbor.

Discharges of seafood wastes into the marine environment are regulated by the Clean Water Act, 1972 (PL 92-500), the Alaska National Interest Lands Conservation Act, 1980 (PL 96-487), and effluent guidelines and standards for canned and preserved seafood (EPA 1980a). Prior to the disposal of seafood and other waste products into waters of the United States a National Pollutant Discharge Elimination System (NPDES) permit must be obtained from EPA. Issuance of the permit for discharges into the territorial sea, the contiguous zone and the oceans is dependent upon Ocean Discharge Criteria (EPA 1980b), as authorized by Section 403 of the Clean Water Act. The criteria are based on the determination of unreasonable degradation, which is defined as:

> "(1) Significant adverse changes in ecosystem diversity, productivity and stability of the biological community within the area of discharge and surrounding biological communities,
>
> "(2) Threat to human health through direct exposure to pollutants or through consumption of exposed aquatic organisms, or
>
> "(3) Loss of aesthetic, recreational, scientific, or economic values, which is unreasonable in relation to the benefit derived from the discharge."

Additionally, NPDES permit conditions must be written to meet water quality standards of Section 303 of the Clean Water Act and state water quality standards (EPA 1983). Specific effluent guidelines for seafood waste discharges into remote waters of Alaska are such that "no pollutants may be discharged which exceed 1.27 cm (0.5 inch) in any dimension (EPA 1980b).

Although a permit is not required by the U. S. Fish and Wildlife Service, Akutan Island (including the marine waters down to mean high water) is part of the Alaska Maritime National Wildlife Refuge (Alaska National Interest Lands Conservation Act of 1980) and is managed to conserve fish and wildlife species in their natural diversity, as well as the marine resources upon which they rely (Wennekens pers. comm.).

State wastewater regulations (18 AAC 72) and water quality criteria (18 AAC 70) have been developed by the Alaska Department of Environmental Conservation (ADEC). The criteria as they apply to seafood waste disposal in remote areas are as follows:

1) seafood wastes should not accumulate on the seafloor, shoreline, or on the surface of water;

2) discharge should not make the water unsafe or unfit for use;

3) a sheen on the water should not be visible;

4) mean fecal coliform bacteria counts shall not exceed 20 FC/100 ml and not more than 10 percent of the samples shall exceed 40 FC/100 ml;

5) dissolved oxygen shall be greater than or equal to 5 mg/l;

6) pH shall not be less than 6.0 or greater than 8.5 and shall not vary more than 0.5 pH units from natural conditions;

7) increases in weekly average temperatures shall not cause weekly average temperatures to increase more than 1°C, maximum rate of temperature change shall not exceed 0.5°C/hr, and the normal daily temperature cycle shall not be altered in amplitude or cycle (ADEC 1983a; Soderlund pers. comm.).

Additional conditions may be added to the state permit. Conditions that are routinely applied to state permits are as follows:

1) screened seafood waste should be discharged below the water surface and at least 0.8 km (0.5 mile) offshore in water 27 meters (90 ft) deep, or;

2) seafood waste shall be ground to a maximum size of 1.27 cm (0.5 inch) in any diameter and discharged 3 meters (10 feet) below the elevation of mean lower low water and 122 meters (400 feet) from mean high water;

3) if seafood wastes are not disposed of by reduction or by screening and transporting offshore by barge, then a dive survey of the waste pile may be required at least once per year. This assumes an accumulation of 45 processing days;

4) a mixing zone may be designated around the outfall (Howe pers. comm.).

The ADEC requires that private landfills or municipal waste sites must obtain an additional permit prior to the reception of seafood wastes (Howe pers. comm.). The application process for this permit is often time consuming and not always successful. A general requirement for the disposal of seafood wastes is that waste material must be stored in "a place and manner that prevents wildlife attraction or access" and that the disposal facility must "keep the premises free of solid waste that may attract disease vectors or create other health hazards" (ADEC 1983b).

The ADEC has developed a State Implementation Plan that has been approved by EPA as meeting the objectives of the Clean Air Act and the National Air Quality Standards. Air quality control regulations in Alaska (18 AAC 50) are such that emissions from seafood waste incineration may not reduce visibility by 20 percent, and particulates may not exceed 0.5 grain (Howe pers. comm.). It is likely that a permit would be required to incinerate seafood wastes at Akutan Harbor. Additional regulations would include the positioning of the incineration plant so that the population center would not be affected by ashfall and odor.

Chapter 5

IMPACTS OF ALTERNATIVES

Several alternatives have been presented that address the fate of seafood processing wastes at Akutan Harbor. The impacts of these alternatives are discussed below, grouped into several categories of concern: water and sediment quality, biological community, beneficial uses of the harbor, City of Akutan, and seafood processing industry. The categorical impacts are integrated in a summary section at the end of Chapter 1.

Water and Sediment Quality Impacts

This section discusses the types of impacts that will result from implementation of the alternatives. The impacts of permitting Trident to resume grinding and discharging through the existing outfall are also discussed in this section.

Benthic Accumulations

Alternatives that do not remove the solid wastes from the marine environment (no treatment, grinding with outfall discharge, outer harbor outfall, barging, and aerobic digestion and discharge), will result in accumulations of solid wastes on bottom sediments. Conversion of shellfish waste to chitin, while removing crab waste, will not alleviate fish waste accumulations.

The location and amount of accumulation will differ between alternatives. No treatment will decrease the rate of decomposition and dispersion, yielding larger accumulations of larger particles near the outfalls. Grinding with outfall discharge will yield a persistent accumulation near existing outfalls that will continue to expand to some degree. The outer harbor outfall discharge alternative will relocate the waste piles by piping the material to the mouth of the harbor. Based on observed circulations in the harbor, dispersion is not likely to occur until the wastes are piped beyond Akutan Point. Aerobic digestion will reduce the quantity of solid wastes which, in turn, reduces the benthic accumulation near the discharges.

Barging to deeper water or the open ocean may result in some accumulations on the ocean bed. However, water currents will disperse the settling material, and the solids will be spread over a large area at reduced thicknesses of accumulation. Thin layers that do not smother benthos will aid in aerobic

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decomposition and may provide a food source to scavengers, deposit feeders, and other detritavores.

The chitin alternative would significantly reduce accumulations near floating shellfish processors but would have little effect on the Trident pile, which is predominantly composed of fish.

Accumulations of seafood wastes will change the physical character of the benthic environment. A blanket of organic wastes will cover the bottom and alter its texture, topography, structure, and chemical composition. As the wastes decompose, oxygen will be consumed and anoxic conditions will rapidly develop within the waste layer. Hydrogen sulfide, ammonia, and methane concentrations will increase as decomposition continues in the anoxic layer. The rate of anaerobic decomposition is much less than aerobic decomposition, extending the duration of coverage if an anoxic state develops.

The incineration alternative would produce a significant quantity of ash. Concentrated ocean dumping of the ash may result in accumulations on the bottom. The ash would be inorganic, and decomposition will not occur. Texture and chemical changes in bottom sediments may result from an ash coverage.

Alternatives that require solids separation may still result in comparatively minor waste accumulations on the bottom. Some fine solids are not removed by the screening process and will settle out and add to sediment depositions. The area receiving these small particles will be large due to the significant dispersion and long settling times that these solids will have. It is reasonable to assume that aerobic conditions will remain and that decomposition will be rapid. Accumulation impacts from these alternatives are expected to be minimal.

Projections for Trident Waste Pile

The major impact of seafood waste discharge into Akutan Harbor detected by the June and September 1983 field investigations was the accumulation of seafood waste on the bottom of the harbor and the associated local impacts on the benthic community.

One objective of this Environmental Assessment is to evaluate the impacts of continued operation of floating processors and resumption of operations at the Trident plant on harbor bottom conditions. Data are generally lacking, however, upon which to base accurate estimates of accumulation volumes and affected bottom areas. Some information is available from a March 1983 dive survey of the Trident waste pile, and this is used to try to bracket the range of impact likely if Trident were to resume operation using grinding and discharge through the existing outfall.

The Trident waste pile is also the largest located on the Harbor bottom by the June investigations. The large capacity of the Trident plant compared to the floating processors currently using the harbor and the different character of the discharge (mostly cod waste from Trident vs. crab waste for floating processors) focuses greater interest in the Trident waste pile.

Caution must be emphasized in interpreting the results of this computation. Full knowledge of the processes involved and the contributing variables does not exist. The Evans Research Group data represents only one data point on which to base the computation, and these data are incomplete for our purposes. No verification is possible due to the limited knowledge of the waste pile's behavior.

A range of projections has been developed to estimate impacts of resumption of waste discharge from the Trident outfall. The estimates are based on a computation of the pile volume from March 1983 dive surveys compared to waste volumes between June 1982 and March 1983 computed from processing records. This comparison is expected to indicate that the volume present in March 1983 was less than the volume of waste discharged, and that the difference would represent decomposition and compression. (Dispersion of solids is judged very unlikely based on video observations of the pile edge.)

The nature of the uncertainties in the data indicates that projections bracketing the probable impact can be obtained by assuming a second case with a slower decay rate. This would, in effect, incorporate an assumption that a considerable volume of the discharged waste has sloughed into deeper waters beyond the reach of the divers.

The following sections discuss the detailed assumptions and computations used in developing the estimates.

Estimation of Waste Decay and Compression Rate. The procedure for estimating the waste decay rate involves making assumptions, gathering input data, and developing decay relationships. Assumptions used in this determination are:

- no dispersion of solids.
- specific gravity of waste that is slightly greater than seawater: taken as 1.06.
- exponential decay and compression rate.

The first assumption is based on circulation patterns and waste piles observed during the Akutan water quality investigations. The low current velocities, persistence of discrete waste piles and video images which indicate sharply defined edges of the waste piles support this no dispersion assumption. The second assumption is based on Brown and Caldwell (1983), who estimated crab and finfish waste densities of 1.2 and 1.06 gm/cm^3, respectively. The third assumption represents that the pile will decay and compress at a rate that is directly proportionate to the pile volume. This yields an exponential decay rate.

The waste discharged from the Trident processing plant has been estimated from Trident purchasing records and body weight ratios from Kizevetter (1971). The cod wastes at Trident consist mainly of the head, backbone, and viscera. Table 10 gives the weight ratios of these parts.

Based on these data, 53 percent of the raw weight (head, viscera, and vertebrae) would have been discharged as solid waste. It is estimated that 6,730 metric tons of cod waste was discharged between June 1, 1982 and March 1, 1983. The total original volume of this waste at a specific gravity of 1.06 would be about 6,350 cubic meters.

Evans Research Group, Inc. conducted an investigation on March 1, 1983 that included dive studies to estimate the waste accumulations. Based on their depth contour map, a waste volume of approximately 3,400 cubic meters is calculated to have existed near the outfall in a very steep-sided conical pile. This value is approximate since the contour lines are incomplete for areas too deep for diver observation.

Evans also reported that 43,904 square meters were covered with cod waste. Of this area, the conical waste pile covered about 12 percent of the total area. A covering of 1 inch (2.54 cm) for the remaining area would add approximately 1,000 cubic meters to the total waste volume. Therefore, assuming a minimum of 1 inch cover, the waste volume on March 1, 1983 is estimated at 4,400 cubic meters.

The exponential decay rate is expressed as follows:

$$X = X_o e^{-kt}$$

Where: X = remaining volume after decay
X_o = original volume
k^o = decay constant
t = time

The assumptions that no waste pile existed in June 1982, that 6,350 cubic meters of waste had been discharged and that 4,400 cubic meters remained as of March 1, 1983 allowed solution of the equation to yield the following decay constants:

$k = 0.136$ per month (base e)
$k = 0.005$ per day (base e)

Muellenhoff (1976) determined an anaerobic decay constant of 0.015 - 0.020 per day for marine benthic sludge deposits, three

Table 10. Body Weight Ratios for Cod*

BODY PART	PERCENT OF TOTAL BODY WEIGHT BERING SEA AUG - OCT	AVERAGE PERCENT
Head	15.3 - 29.6	22.5
Fins and Tail	2.5 - 9.2	5.9
Viscera	10.4 - 28.3	19.4
of which liver	3.2 - 6.0	4.6
Trunk	43.2 - 53.4	48.3
Vertebrae	6.0 - 15.4	10.7
Flesh Without Skin	38.7 - 44.8	41.8

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* Source: Kizevetter 1971

to four times larger than determined for Akutan (0.005 per day). However, the decay process is proportional to temperature and, adjusting for the low temperatures at Akutan (5°C), the calculated Akutan decay constant is just outside of the minimum of Muellenhoff's range. This represents a best case scenario decay rate, i.e., leaving 70 percent of the total discharge still in place on 1 March 1983. If the waste volume is in reality larger than the estimated 4,400 cubic meters, a smaller decay constant would be appropriate. The worst case scenario would be zero decay; the continual waste addition would result in a continual growth of the pile. Since zero decay is unrealistic, a more reasonable worst case scenario is described by 90 percent of the total discharge still in place on 1 March 1983 (i.e., 5,715 cubic meters waste). This results in a calculated decay constant of .074 per month, or 0.0025 per day (base e).

The equation was tested to determine the sensitivity of the results to changes in assumptions. The sensitivity analysis (Table 11) shows: (1) underestimating dispersion and pile size results in a faster decay rate, and (2) underestimating waste specific gravity and initial waste input results in a slower decay rate. Parameters were varied ±10 percent (dispersion increased from 0 to 10 percent, and specific gravity ±5 percent) and resulted in decay constants that are within the range presented in the best and worst case scenarios. When parameters were varied jointly in complementary fashion, changes in the decay constant are similar to the worst case scenario. Therefore, the scenarios are felt to encompass the likely range of decay constant.

Benthic Areal Coverage. With this equation, it is possible to project how the Trident waste pile would grow if the plant resumed discharges through its existing outfall. The decay rate has been found to vary depending on the assumptions used to substitute for missing data that describe the pile on March 1, 1983. Two decay rate scenarios (best case k = 0.136, and worst case k = 0.074) are used in the following determination. Crab wastes were assumed to decay much slower at a decay constant half that of cod.

Other assumptions that have been made involve processing activity, pile shape, and pile growth.

For computation purposes, it is assumed that cod would be processed year-round at plant capacity (600,000 pounds or 272 metric tons processing per day), crab processing would equal September 1982 production (12,500 pounds or 5.6 metric tons per processing day) for the September-April period, salmon processing would equal August and September 1982 production (5,000 pounds or 2.3 metric tons per processing day) for the May-August period, and herring processing would equal August and September 1982 production (50,000 pounds or 23 metric tons per processing day) for the August-September period. Decay rates

Table 11. Sensitivity Analysis

Equation Form: $X = X_o e^{-kt}$
k = 0.136 per month Base e
k = 0.005 per day base e

PARAMETER	CHANGE	% CHANGE IN k	ORIGINAL VALUE	k ($month^{-1}$)	k (day^{-1})
Dispersion	from 0 to 10%	- 19	0	.110	.0037
Specific Gravity	+ 5%	7	1.06	.146	.0049
Specific Gravity	- 5%	- 9	1.06	.124	.0041
Waste Quality	+ 10%	18	.53	.160	.0053
Waste Quality	- 10%	- 18	.53	.112	.0037
Pile Volume	+ 10%	- 17	4400	.113	.0038
Pile Volume	- 10%	21	4400	.164	.0055
Combination	10% Dispersion, -10% waste, + 10% Pile Volume	- 52	-	.065	.0022
Combination	+10% Waste, -10% Pile Volume	40	-	.190	.0063

were based on the determined decay constant discussed previously. Fifteen processing days per month were also assumed.

The pile shape on March 1, 1983 was only partially described by Evans Research Group (1983), and showed a cone-shaped pile near the discharge. Unfortunately, the deep-water edge of the cone was undefined. A significant area (approximately 9 acres) was covered with wastes in addition to the acre probably covered by the main, cone-shaped pile. For modeling purposes, two representations of the pile are made, differing in the relationship between waste volume and bottom coverage. The first uses a fraction of a straight-edged cone, the second an exponential decline in depth of waste deposits, which is then mathematically integrated and revolved. Both models transform the bottom area into a circle with maximum depth linearly proportional to circle radius.

The first model represents a waste pile that is very cohesive and does not readily slump and spread over the bottom. The second model represents a waste pile that tends to have a high peak, but the surrounding wastes decrease in depth rapidly and spread out on the bottom. Model results are presented for the first ten years in Table 12. Ranges result from varying the decay constant between 0.136 and 0.074. A significant difference in areal coverage occurs between the two models. The worst case decay rate (0.074) and the exponential model yield depths of deposit that exceed water depth at the current outfall site after three years.

The cone fraction model, using either decay rate, indicates steady state will be reached after four years. Steady state occurs when the quantity that decays in the large pile is equal to the input volume. The best case decay constant and the exponential model yield pile depths that reach a constant height of 23 meters and areal extent of 93 acres, also after four years.

Interpreting the results in Table 12 leads to several conclusions:

1. Additional observations on depths of waste are needed to refine the model calculations, if this alternative is permitted.

2. Significant waste accumulations are predicted even under best decay rates and pile characteristics.

3. Both models predict steady state results in about five years.

Prior to applying these conclusions to the waste pile, one must be reminded that many major assumptions have been made and that the data set is very limited. The models are best used as guides to what might happen if maximum production occurs. Allowing for these limitations, it is possible to predict that:

Table 12. Predicted Maximum Depth and Areal Coverage after 10 Years Discharge

YEAR[1]	CONE FRACTION MODEL depth (m)	CONE FRACTION MODEL area (acres)	EXPONENTIAL DEPTH MODEL depth (m)	EXPONENTIAL DEPTH MODEL area (acres)
1	10.3-11.4	19-23	18.3-25.3[2]	59-113[2]
2	10.9-12.8	21-29	21.9-35.8[2]	84-226[2]
3	11.0-13.3	21-31	22.8-40.0[2]	91-282[2]
4	11.0-13.5	21-32	23.0-42.9[2]	93-311[2]
5	11.1-13.6	22-33	23.0-43.3[2]	93-324[2]
6	11.1-13.6	22-33	23.0-43.3[2]	93-330[2]
7	11.1-13.6	22-33	23.0-43.3[2]	93-330[2]
8	11.1-13.6	22-33	23.0-43.3[2]	93-330[2]
9	11.1-13.6	22-33	23.0-43.3[2]	93-330[2]
10	11.1-13.6	22-33	23.0-43.3[2]	93-330[2]

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[1] Discharge initiated in January; December values presented.

[2] Upper range depths and related areas exceed the current depth of the outfall and do not accurately represent the Trident waste pile.

1. Significant waste accumulations will result from seafood processing waste discharges in Akutan Harbor.

2. Except for a no decay situation, a steady state waste volume will result.

3. A no decay situation would result in an ever increasing waste accumulation, but the incremental increase will be less noticeable as the volume of accumulating material becomes proportionally greater.

4. The steady state waste volume may fluctuate in shape which would vary the areal coverage.

Water Quality Impacts from Discharge

All alternatives will continue to discharge the liquid waste stream into the inner harbor. This liquid waste stream has not been analyzed for the existing discharges to Akutan Harbor. Composition of the waste stream will vary depending on the handling of the waste prior to discharge. Average waste loadings from the Alaskan whole crab and sections and fish meal processing industry subcategories have been estimated by EPA (1981) and Edward C. Jordan Co. (1979). Table 13 presents these loads. Data reported in Table 13 are applicable only to alternatives that include screening. No estimates are given for the Alaskan bottomfish subcategory because of insufficient data.

Alternatives that require screening will improve receiving water quality by reducing total suspended solids, BOD, and oil and grease concentrations (Edward C. Jordan 1979; EPA 1974). Grinding will solubilize part of the waste and release body liquids contained in the larger waste pieces; therefore, the no treatment alternative may result in lower TSS, dissolved BOD, and oil and grease concentrations than the grinding and discharge alternative. Aerobic digestion and discharge will probably reduce the dissolved BOD and TSS concentrations prior to discharge.

Alternatives that result in accumulations around the discharge (no treatment, grinding with outfall discharge, possibly outer harbor discharge, and probably aerobic digestion), and that bury the outfall result in the discharge of solid and liquid waste through the overlying wastes. This discharge will mix with the interstitial waters of the waste pile, that, under anoxic conditions, will have significant dissolved concentrations of hydrogen sulfide, ammonia, and possibly methane. This will degrade the quality of the effluent that eventually enters the water column, but may improve decomposition rate of the pile.

Quantification of the impacts of discharging effluent through a decomposing waste pile are difficult to estimate.

Table 13. Waste Loads for Seafood Processing Subcategories[1]

CATEGORY	FLOW 1/kkg	BOD kg/kkg	TSS kg/kkg	O&G kg/kkg
Alaska whole crab and sections	20,000 - 21,000	6.14	1.86 - 3.94	0.452 - 0.581
Whole fish meal	16,400 - 17,400	3.08 - 4.46	1.16 - 3.43	0.623 - 1.02
Hand butchered salmon	3,420 - 5,220	2.52	0.787 - 1.15	0.146 - 0.185
Non-Alaskan bottomfish, manual	3,980 - 6,210	3.17	1.30 - 1.69	0.378 - 0.604
Non-Alaskan bottomfish, mechanized	12,800 - 14,900	13.6	8.77 - 8.86	2.75 - 3.32

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[1] Source: EPA 1981 and Edward C. Jordan Co., Inc. 1979; ranges are given when data differ between sources or not given by both sources.

Factors which would need to be considered include: waste depth, discharge frequency and duration, discharge volume, interstitial volume, decomposition rate and processes, and waste characteristics. Qualitatively, the potential for effluent of very low quality exists when effluent must flow through an anaerobic waste pile. A water quality impact would be greatest when discharge commences after a period of no discharge.

Discharges that will not flow through waste piles (barging, landfill, fish meal, chitin, other by-products, and incineration) include a screening step; waste loads, therefore, should approximate those given in Table 13. Loads from Alaska bottomfish processing are not known and are approximated by annual non-Alaskan bottomfish loads. Actual waste loads from Akutan processors have not been determined. The BOD, TSS, and oil and grease estimated loadings are presented in Table 14.

The BOD loading (after screening) from a typical daily wastewater discharge during crab and bottomfish processing from a mean of 7.4 crab processors and Trident's facility would be approximately 4 metric tons. With a dissolved oxygen concentration of 9 mg/l in the receiving waters, 450 million liters (450,000 cubic meters) of harbor water would be needed to meet this oxygen demand. This is approximately 0.06 percent of the mean volume of the harbor. This represents a theoretical volume of water that becomes anoxic because of the discharge. In practice, however, the water mass is not static or unmixed, so the volume of water impacted by the discharge is greater, and the magnitude of oxygen depletion is proportionately less. Based on a minimum residence time of 5 days and a minimum acceptable oxygen concentration of 5 mg/l, a minimum of 0.7 percent of the harbor volume is needed to meet the oxygen demand. In the nearfield, a minimum of 1:75 dilution is needed to prevent oxygen concentration in the receiving water from decreasing to below 5 mg/l (based on average effluent BOD of 300 mg/l).

Water Quality Impacts from Benthic Accumulations

No treatment, grinding with outfall discharge, outer harbor outfall discharge, aerobic digestion, and barging alternatives will most likely result in benthic accumulations of waste. As these wastes decompose, they exert an oxygen demand on the overlying waters that may depress the nearfield dissolved oxygen concentration. Anaerobic decomposition resulting in hydrogen sulfide, ammonia, and methane production may also cause a flux of these compounds into the water column. The impact of these processes on the water column quality of Akutan Harbor was not evident during the field investigations. Therefore, impacts on water column quality from benthic accumulations are not likely to be significant.

Table 14. Estimated Annual Loadings of BOD, TSS, and Oil and Grease for Akutan Harbor for Screened Alternatives

CONTRIBUTOR	BOD metric tons	TSS metric tons	OIL & GREASE metric tons
7.4 crab processors[1] @ 2,000 metric tons each	94	28-52	6-8
4 crab processors @ 1,500 metric tons each	37	11-24	3
272 metric tons bottomfish x 180 days[3]	155[4]	64-83[4]	19-30[4]

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[1] 1978-1982 Average number of shellfish processors and production.

[2] 1982 Number of shellfish processors and production.

[3] Maximum production at previous Trident facility assuming 180 days production.

[4] Based on manual non-Alaskan bottomfish.

Additional Wastewater Discharges

Alternatives that expand processing activities (fish meal, chitin/chitosan, other by-products, and incineration) will also create an additional wastewater used for cleaning, cooling, and processing. Pollutants from these discharges include BOD, TSS, heat, and oil and grease. Proper plant design will minimize these pollutants and decrease potential water quality impacts. The fish meal alternative is a seafood processing subcategory; waste loading is estimated in Table 13. A whole fish meal facility that would process a single day's waste from the Trident facility (144 metric tons) would discharge a BOD of approximately 0.45-0.65 metric tons. This would increase the daily wastewater loading presented earlier by 10-15 percent.

The landfill alternative has the potential for leachate and erosion problems. Precipitation may percolate through the landfill, dissolving and absorbing waste-related compounds. This flow could percolate into nearby streams or directly into the marine environment. The impact on these water bodies will depend on the soils characteristics, landfill design, quantity and quality of leachate, points of discharge, and resulting mixing and dispersion. A reduction in dissolved oxygen and possible low concentrations of hydrogen sulfide may be particularly noticeable in the small local streams. Increased erosion will result from the landfill activities, causing sedimentation in the nearby streams.

Waste Disposal Impacts on Biological Communities

Marine Communities

Disposal of seafood wastes into Akutan Harbor through either direct discharge without treatment or with grinding and outfall discharge would have its greatest impact on less mobile benthic organisms such as polychaetes and bivalves. Benthic organisms within the area of waste accumulation would be subjected to anaerobic conditions and smothering effects, as well as changes in TOC content, and TSS, dissolved hydrogen sulfide, and ammonia. Direct discharge without treatment would have a greater effect on the biota because of the slower decay and greater accumulation rate of the untreated waste.

The June and September 1983 field surveys at Akutan Harbor provide evidence for changes in the benthic community associated with seafood waste discharges under current practices. It was evident that persistent waste piles on the harbor floor had killed biota beneath them (Jones & Stokes Associates 1983). Grab samples from an old waste pile off the Akutan Village dock, which had received little waste during the past 5 years, indicated that the effect of crab waste piles is persistent. The biological community associated with this waste pile contained species approximately similar to those found in background locations, although several major differences were apparent. Gastropods were not observed at the old waste pile, whereas the abundance of *Echiuris echiuris*, especially juveniles, and rare species (found only once at one station) was greater at the old waste pile. The abundance of *E. echiuris* is indicative of large quantities of organic detritus in the water column.

Differences in the benthic community were also observed near the perimeter of the waste piles. The perimeter bottom consisted of a thin layer of aerobic sediment over anoxic muds. Species richness in the aerobic layer was generally lower than at background locations and higher than at the waste pile (Table 15). One of the samples at the perimeter was dominated by the polychaete, *Capitella* sp. A, a species indicative of high organic pollution. Overall abundance of organisms tended to be lower at the perimeter, although visual observations with the underwater video camera (UVC) indicated an abundance of Tanner crab (*C. bairdi*) at the waste perimeter compared to the lack of crabs on the waste pile and lower number of crabs at background locations. Apparently, the crabs were attracted to the waste pile perimeter for food, but avoided the anoxic condition of the pile itself.

The distance at which an impact from seafood waste discharges can be detected in Akutan Harbor is unclear. Evidence from the June and September 1983 field surveys indicates a possible long distance effect caused by the discharge plume. Generally, high species diversity indicates a healthy environment. In June, an area of unusually low species diversity was detected southwest of the Trident outfall. Modelled water current and flushing patterns indicate that east winds, which are the major force driving circulation in the inner harbor, may cause the discharge plume to flow in a southwesterly direction (Jones & Stokes Associates 1983). Thus, the lower species diversity of this inner harbor community may have been a result of the discharge plume. It is not known whether this community was responding to settling solids, high BOD, or dissolved sulfide or ammonia in the plume. Samples from the September survey indicate this community may be recovering, possibly as a result of the cessation of waste discharge from the Trident outfall in June. A greater number of species, including species represented only by juveniles, were observed in this community in September.

The effect of direct discharge of seafood waste without treatment, or with grinding, on most fishes, birds, and marine mammals is likely to be less severe than to benthic organisms. Most fishes, birds, and mammals will probably avoid areas that may cause harm. Furthermore, the relatively small change in the concentration of hydrogen sulfide, un-ionized ammonia, and dissolved oxygen observed in the water near the waste pile (Jones & Stokes Associates 1983) suggests that most fishes should not be significantly affected by water quality changes. Seagulls and other scavengers may be attracted to recent discharges that rise to the water surface, but are likely to be

Table 15. Number of Benthic Species and Codominant Species at Akutan Harbor and Akutan Bay

AREA	NUMBER OF SAMPLING STATIONS	MEAN (RANGE) OF SPECIES NUMBER/STATION	CODOMINANT SPECIES
Inner harbor, June[1] (southwest of Trident outfall)	2	6 (4-7)	*Boccardia*/*Scalibregma*
Inner harbor, September[1] (southwest of Trident outfall	3	17 (13-20)	*Ninoe*/*Boccardia*/*Axinopsida*/*Prionospio*/ *Macoma moesta*/*Scalibregma*
Inner harbor[1] (background)	13	18 (13-25)	*Boccardia*/*Macoma moesta*/*Ninoe*/*Prionospio*/ *Axinopsida*/*Laonice*/*Scalibregma*
Trident waste pile[1]	5	2 (1-5)	*Boccardia*/*Axinopsida*
Waste pile perimeter[1]	6	10 (3-17)	*Boccardia*/*Scalibregma*/*Capitella*/*Macoma moesta*/ *Echiuris*/*Prionospio*/*Nereis zonata*
Old waste pile[1]	5	15 (12-18)	*Boccardia*/*Echiuris*/*Prionospio*/*Scalibregma*/*Ninoe*
Outer harbor[2]	9	23 (10-31)	*Macoma moesta*/*Axinopsida*/*Ninoe*/*Prionospio*/*Euclymene*/ *Travisia*/*Boccardia*/*Mediomastus*
Akutan Bay[3]	10	29 (23-43)	*Axinopsida*/*Macoma moesta*/*Mediomastus*/*Prionospio*/ *Nuculana*/*Harpinia*/*Ninoe*

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[1] Sieved with 1-mm mesh screen

[2] Five of nine samples sieved with 0.5-m mesh screen (Nematodes in fine [0.5 mm] portion)

[3] Sieved with 0.5-mm mesh screen (Nematodes in fine [0.5 mm] portion)

Source: Jones & Stokes Associates 1983

repelled by any anoxic wastes that may surface during the discharging of wastes. Marine mammals may visit the waste pile on occasion, but are not likely to be adversely affected.

The major impact of nearshore solid waste discharges to fishes is likely to be disruption and displacement of juvenile pink and coho salmon, sand lance (A. hexapterus), daubed shanny (L. maculatus), and other burrowing fishes. Numerous juvenile pink and coho salmon have been observed in Akutan Harbor (Crayton 1983) and probably feed extensively in the nearshore habitat, although the significance of this habitat to the salmon in Akutan Harbor is undocumented.

Sand lance, which burrow into the sand during the night, are abundant in Akutan Harbor (Crayton 1983) and are obviously displaced by seafood waste accumulations. Sand lance are an important forage fish for other fishes, birds, and marine mammals, but it is unlikely that waste accumulations in Akutan Harbor would be great enough to significantly reduce the population of sand lance and affect the predator populations. Observations of the seafloor with a UVC indicate daubed shanny, which also burrow into the sand, are notably less abundant near the waste pile at Akutan Harbor than at background locations.

The effect of discharging seafood wastes directly into the outer harbor or screening the effluent and barging the solid waste to a deep water location will depend on the degree of waste dispersion. Sufficiently dispersed and diluted seafood waste is likely to increase productivity rather than cause an anaerobic environment. If the waste is continually deposited in the same local area, then the adverse effects are likely to approach those of direct nearshore discharge. Organisms that could be killed by concentrated deposition of waste in outer Akutan Harbor or Akutan Bay include numerous bivalve, crustacean, gastropod, polychaete, and other species. It is likely that outer harbor discharges will be dispersed better than nearshore direct discharges and that the overall adverse effects of outer harbor discharges will be less.

The chitin/chitosan and aerobic digestion alternatives would remove a portion of the solid waste from the effluent discharge. The effect of these alternatives on the marine biota would be similar to those caused by direct discharge with or without grinding, except that the magnitude of the adverse effect would be less. The adverse effect of the chitin/chitosan alternative could be greater than that of the aerobic digestion alternative because only shellfish wastes would be screened. The adverse effect of these alternatives could be lessened if the wastes were distributed over a large area such that the wastes acted to increase productivity and not cause depositional stress to benthic organisms.

Several of the discharge alternatives (screening with barging, landfill, fish meal production, other fish by-product production, incineration) require screening of the waste to remove most of the solids. The liquid fraction of the waste that is discharged into the nearshore environment of Akutan Harbor would result in BOD, TSS, oil and grease, and possibly heat loading near the outfall. The benthic community near the liquid fraction outfall could experience some changes in species composition (depending on the elevation of the outfall above the seafloor). The effects of this waste stream would be small compared to effects of direct discharges that include solids.

Although additional waste products would be associated with the fish meal alternative, the elevated levels of BOD and temperature in the liquid fraction would not cause a significant change of effects. The incineration alternative may also create additional wastes in the liquid fraction, and may cause slightly greater impacts on the biota than the other alternatives that require screening. The large quantities of ash created by incineration could cause significant depositional effects if the ash were continuously discharged into a local area. The overall impacts of the landfill, fish meal production, other fish by-product production, and incineration alternatives on the marine environment would be less than the direct discharge alternatives with and without grinding.

Terrestrial and Freshwater Communities

The landfill alternative would affect the terrestrial biota. Placement of a seafood waste landfill at the head of Akutan Harbor could severely affect the fishes living in the two streams. Numerous pink salmon and fewer coho salmon and Dolly Varden inhabit the larger stream at the northwest corner of the harbor. Landfill activities and road construction near or in this stream could disrupt the fish habitat by increasing sediment levels in the water and spawning gravel, and possibly by blocking the migration of salmon and Dolly Varden. Leachates from the waste may also affect the aquatic organisms if leachates reach the stream. A landfill at the head of the harbor would also destroy one of the larger wetland areas near Akutan Harbor. Placement of a landfill at upland locations would cause local destruction of the tundra habitat, as well as a loss of tundra habitat caused by the construction of a road. Freshwater and marine environments could be affected by leachates and by the erosion of sediment associated with the landfill and road construction.

The incineration of seafood waste would probably not cause significant effects on the terrestrial biota of Akutan Island. The winds of the Aleutian Island area are generally strong (average monthly windspeed ranges from approximately 5 to 20 knots per hour [NOAA unpubl.]) and would disperse airborne emissions over a large area. However, it is possible that a nearby portion of tundra habitat could be affected by emissions that are continually directed over the island. Local changes that could occur include a shift in vegetation composition and possibly a reduction in the abundance in vegetation. Vertebrate species would probably not be significantly affected.

Impacts on Beneficial Uses of Harbor

Minimal impact on harbor use is anticipated from the grinding with outfall discharge and deep water discharge alternatives. Navigation may need to be restricted above an outfall pipe and discharge to minimize the risk of anchor damage to the system.

Increases in harbor traffic will result from all other alternatives except for aerobic digestion and discharge. Congestion is not likely to result, although additional docking and loading/unloading activities may at times cause delays. A benefit may result if additional traffic decreases shipping times and adds flexibility in transport planning. Barging and landfilling will not add this benefit due to the local extent of their associated traffic.

Aesthetic impacts, including noise and odors, will result from landfilling, fish meal reduction, aerobic digestion and discharge, and incineration. Proper system design and location can minimize these impacts.

The landfill alternative will also restrict future land usage and restrict activities within the dedicated area. This will decrease potential future uses of the harbor and associated benefits.

Impacts on City of Akutan

Continued processing activity in the harbor will maintain existing adverse impacts on the harbor. These impacts include occasional oil sheens from boat traffic and tainted clam flesh (presumably as a result of boat discharges). No new impacts are anticipated to result from no treatment, grinding with outfall discharge, and deep water discharge.

Odor impacts could affect the village residents from the screening and barging, incineration, landfill, aerobic digestion, fish meal production, chitin production, and other alternatives which involve storing and handling fish processing wastes. Wind conditions may direct odors to the village under variable wind conditions depending on the location of the source. Odors may also affect villagers using the harbor during recreation and subsistence activities.

A potential for decreased revenue exists if the amount of processing carried out in the harbor decreases as a result of alternative implementation. The City collects 50 percent of the state's raw fish tax levied on processors within the harbor (City of Akutan 1982). Also, some employment opportunities may be lost with a production decrease. A sales tax also exists but little or no consumption of Akutan products by the temporal processing population currently occurs.

Due to the year-round operating nature of the fish meal alternative, the City may benefit from increased employment opportunity.

The incineration and barging alternatives offer a possibility for joint solid waste disposal and ash disposal. The City is actively pursuing the purchase of an incinerator and may be able to combine disposal efforts with the processors. Cost benefits would be possible with this cooperative venture.

The only land possibly suitable for landfill exists at the head of the harbor and is currently owned by the Native Corporation. The implementation of the alternative would mean revenue from the land sale/lease but also would curtail resident activity, such as hunting, in this area, and in offsite areas affected by topsoil removal.

Impacts on Seafood Processing Industry

The grinding with outfall discharge alternative would have little impact on the industry. Akutan Harbor would continue to attract seafood processors, and, if appropriate permits were issued by EPA, waste disposal via grinding and discharge would most likely continue.

The no treatment alternative is currently not permitted and legislative changes would be necessary for its implementation. The industry could benefit from the lower cost of not owning and operating grinders, but pipe maintenance could also increase due to additional clogging.

The industry benefits from the inherent flexibility of floating processors. These ships can relocate to areas closer to fishing grounds or to areas that offer better conditions. An alternative that is specific to Akutan Harbor will be a factor in a floating processor's decision to locate in the harbor. Therefore, restrictions placed on Akutan Harbor may cause a flux in the industry's processing centers. The Trident land-based facility does not have this flexibility, thus harbor restrictions will be a factor in this facility's operating procedures.

Several alternatives require investment with no possibility of economic return; deep water discharge, barging, landfilling, aerobic digestion and discharge, and incineration. The added cost will decrease the profitability of the industry and may force closure of marginal operations. Increases in consumer prices of the seafood products may also occur to cover the alternative cost. The requirement of these alternatives will likely result in an industry reevaluation of other less costly or even profitable reuse options.

Alternatives that produce a new marketable product such as fish meal, fish silage, chitin/chitosan, and other fish by-products will have additional impacts on the industry. The markets for these new products would require varying degrees of development. Administrative branches would need to expand to manage the logistics and other factors relating to producing these new products. The labor force would also expand to fulfill the new jobs associated with the alternatives. The company would also be introducing its name in a new market, thereby expanding its recognition.

Chapter 6

COMMENTS AND COORDINATION

This chapter describes coordination during preparation of the Environmental Assessment, including contacts with the City of Akutan and seafood processors operating in Akutan Harbor.

Community Contacts

Contact was made with City of Akutan officials during June and September field studies. Additional telephone contact was made with the City's administrative office in Anchorage.

June contacts included a meeting with Mayor Jacob Stepetin to discuss the water quality surveys and gain information on the uses of the harbor and their importance to the village. Team members also attended a planning commission meeting to discuss the water and sediment sampling work and the city's interest in acquiring an incinerator for solid waste disposal. Details on discussions of these meetings are contained in Appendix A to the Water Quality Analysis Report (Jones & Stokes Associates 1983).

September contacts included discussion with Mayor Stepetin, who joined the crew of the F/V Karin Lynn for the water quality and sediment sampling. Team members also met with the City Council and other citizens in September to discuss the water quality and sediment surveys, as well as the incinerator acquisition. Details on these contacts are contained in Appendix A to this document.

Processor Contacts

Contact was made with all processors that were present in Akutan Harbor in June 1983. This included Trident Seafoods, the M/V Deep Sea, and the M/V Western Sea. Summaries of these meetings are reported in Appendix A to the Water Quality Analysis Report (Jones & Stokes Associates 1983).

Subsequent contact was made with four processors who operate in Akutan or Dutch Harbor to discuss the constraints, problems, costs and other factors bearing on seafood waste disposal issues in remote locations such as Akutan. Meetings were held with Universal Seafoods, Inc. (operators in Dutch Harbor and other locations), Trident Seafoods, Inc., and Icicle Seafoods (past operators of Akutan and operators of fish meal plants in Petersburg and Seward). Contact was also made with Deep Sea Fisheries (operators of the M/V Deep Sea at Akutan), but no meeting could be arranged.

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The information derived from these meetings was considered in describing constraints imposed by the harsh conditions and remoteness of Akutan. Cost and practicality information offered by the processors was considered during preparation of cost estimates, but all costs used in this assessment were independently derived.

It was interesting to note that Icicle Seafoods indicated that operation of product recovery plants at Petersburg and Seward was less costly for them than screening and barging. The company also believed that the market exposure involved in selling products (fish fodder, bait, and others) increased their name recognition.

Chapter 7

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APPENDIX A

September Survey Report

Curt

Report on Akutan Harbor Sampling Trip; September 15-21, 1983

Gary Voerman GSV
Water Resources Assessment Team

The File

The following is a cronological description of the activities of the Akutan Harbor Sampling Team:

September 15, 1983

The following people assembled in Anchorage for the charter flight to Dutch Harbor at 1:00 p.m.; Harvey Van Veldhuizen and Alice Godbey (Jones and Stokes Associates, Inc.), Gary Bingham and Tom Dillard (Tetra Tech, Inc.), Lee Rodgers (Alaska Dept. of Fish and Game) and myself. We arrived in Dutch Harbor at approximately 6:00 p.m., loaded equipment on the Karin Lynn (Crab Boat/Trawler) and were underway to Akutan by 9:30 p.m. The mayor of Akutan, Mr. Jacob Stepetin, was aboard and assisted us throughout the trip.

September 16, 1983

We arrived in Akutan Harbor at approximately 2:30 a.m. and began the sampling project at approximately 7:30 a.m. with the placement of four transmitters which provide signals for the Mini-Ranger. The Mini-Ranger system allowed an accurate determination of our position in the harbor. The weather was windy (20 plus knots from the east) and rainy. The entire day was spent gathering water quality and sediment samples. Most of the designated sampling sites were covered. Parameters measured included dissolved oxygen, turbidity, pH, salinity, temperature, secchi disc transparency, and depth. The temperature data did not indicate any stratification in the harbor. Dissolved oxygen was close to saturation at all stations and all depths. There was a fairly consistent discrepancy between the D.O. values obtained with the Martek Mark VIII water quality probe and those obtained using the Winkler method. Gary Bingham indicated that Tetra Tech will have the probe calibration lab attempt to determine the cause of this discrepancy. The pH meter used for the sediment samples was not functioning properly and its use was discontinued.

I talked with Mayor Jacob Stepetin about the current solid waste disposal problems of the village of Akutan (population 65 people). The villagers either burn their garbage on the beach or store it in boxes until wind conditions are favorable. The ash is carried away by the next high tide or the garbage bags are thrown into the water during a strong west wind (so-called "garbage wind"), which is the prevaling wind in the harbor. The village has not yet selected an incinerator but when they do it will be located just east of town within 20 feet of the water's edge. There

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appears to be at least one potential solid waste disposal site approximately one-quarter mile east of Akutan but Jacob was unaware of any studies which may have evaluated the site. It was suggested by myself and Harvey that a meeting with the citizens of Akutan concerning EPA's activities in the harbor would be appropriate. We suggested the evenings of Sept. 17 or 18 as candidates. Jacob agreed that a meeting would be desirable and offered to announce it as soon as we determined which day would best fit our sampling schedule.

September 17, 1983

We finished the Water Quality and Sediment sampling, in high winds (35-40 knots from the east) and rougher seas, for all stations except the outer (41 fathom) harbor optional disposal site. All the current drogues were deployed and would be tracked for the next 2-3 days.

It is evident that a small skiff would have a difficult time navigating during rough weather and therefore an ash storage area would be necessary. If such an area is not provided (or if it contains insufficient capacity) it is likely that the ash will be disposed of on the beach or just offshore. None of the seafood processors were operating while we were in Akutan harbor and it was therefore not possible to obtain any effluent samples.

September 18, 1983

We continued to track the drogues and completed all sediment and water quality sampling, including those requested at the optional outer harbor (41 fathom) disposal site. Video tape recordings of the bottom were made at several sites including the proposed inner and outer harbor disposal sites, the Trident waste pile and the Akutan dock area. The still camera (Benthos) had an inadequate power supply and could not be used.

Since we would complete most of the studies by evening it was suggested that we consider returning to Dutch Harbor immediately. We decided not to return for the following reasons:

1. We needed to meet with the residents of Akutan to explain our presence in the harbor and answer questions.

2. I needed to investigate the possibility of land disposal of solid waste near the city of Akutan.

3. There was a need to take sediment samples at the optional outer harbor disposal site.

4. It would be somewhat dangerous to remove the Mini-Ranger transmitters at night and we would not be able to locate and retrieve the drogues.

5. We would probably not be able to fly out of Dutch Harbor the following day as the visibility [illegible].

Harvey and I held a meeting with the citizens of Akutan while the others took sediment samples at the optional outer harbor disposal site. We met with the mayor and 10 citizens in the community center at 8:00 p.m.

I explained EPA's role in the Ocean Disposal process and gave a brief outline of the procedures necessary for designation of an ocean disposal site. Harvey explained the purpose of the studies we were conducting in the harbor and presented some of the results of the information gathered in Akutan harbor in June of 1983. The citizens had several questions on the designation of the ocean disposal site and the impacts of the Trident waste pile on water quality in the harbor. Questions included the following:

> What conditions will be included in the permit?
>
> How large a skiff will be required to transport the incinerated waste to the disposal site?
>
> Is it likely that Akutan's refuse will have a significant impact on the environment?
>
> When will the permit be issued?
>
> What is the purpose of the drogues?
>
> What are the impacts of the Trident waste disposal pile on the clams in the harbor?
>
> What is the impact of gas emanating from the Trident waste disposal pile?

The citizens indicated that the clams harvested west of the Trident plant had decreased in number and had developed a "diesel taste" recently.

Harvey and I answered the questions to the best of our abilities and, I believe, to the satisfaciton of the citizens present. The primary concern of the residents and EPA is the impact of the Trident waste pile on the harbor environment.

I asked the citizens to submit any subsequent questions to me through Jacob. The meeting ended at approximately 9:00 p.m.

September 19, 1983

I visited Akutan with Jacob while others retrieved the drogues and Mini-Ranger transmitters. I discovered two possible solid waste disposal sites east of the village. They are currently connected to Akutan by a foot path. Development of these sites for solid waste disposal would necessitate the construction of a narrow road. The first site is approximately 1/4 mile from the city and is 5-10 acres in an area with slopes no greater than about 10 degrees. The second site is located approximately one-half mile east of the city. It is 3-5 acres in area with more flat land than the first site. The use of either site would depend upon the soil depth (i.e., the availability of cover material). The first site contained a significant amount of surface water.

There is a considerable amount of refuse on the beach near Akutan. It is obvious that current disposal practices do not result in removal of the village's solid waste from the harbor environment.

We left Akutan at approximately 1:00 p.m. and arrived at Dutch Harbor at 6:00 p.m

September 20, 1983

The equipment was unloaded from the *Karin Lynn* by 9:00 a.m. and transported to the Dutch Harbor Airport. The flights to Anchorage were delayed due to poor visibility and we were not able to leave Dutch Harbor until 6:00 p.m. We arrived in Seattle at 5:45 a.m. September 21, 1983.

The trip was very successful as to the information gathered. The success can be attributed to two basic factors:

1. The excellent organization and follow-through by Harvey Van Veldhuizen and

2. The dedication of all the people involved in the sampling effort.

cc: Robert S. Burd
Dick Thiel
Bill Riley
Harvey Van Veldhuizen
Ron Lee